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Applied Information Technology (IT) For Ship Design, Production and Lifecycle Support: A Total Systems Approach

by

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BS Chemical Engineering
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SUBMITTED TO THE DEPARTMENT OF OCEAN ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREES OF

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ABSTRACT

This thesis analyzes the material flows, manpower usage, administrative requirements and procedures, and technical interface needs employed in the logistics systems onboard aircraft carriers and submarines to determine where Information Technology (IT) could be applied to reduce lifecycle costs and manning demands. The concepts and recommendations derived from this study support the "Focused Logistics" pillar of Joint Vision 2010 (JV 2010), and guidance of the Federal Acquisition Streamlining Act (FASA), the Federal Acquisition Reform Act (FARA), and DoD Directive 5000.1 (March 15, 1996) to incorporate proven commercial business practices into DoD processes.

The first step was to baseline the existing logistics infrastructure for two platforms, namely the aircraft carrier and the submarine, to identify what could be done with IT to make the process more effective. In addition, a broad area search of Navy-wide logistics IT insertion initiatives, and numerous discussions with logistics experts across the Navy and their supporting contractor base were made to ensure that recommendations would be pertinent to current issues. Once the data was all compiled, it was analyzed to identify any gaps which could be potentially solved through the insertion of IT. This analysis indicated that the computer migration plan under the Naval Tactical Command Support Systems (NTCSS) application programs was progressing smoothly, and that the communication connectivity issues associated with exchanging real time data were also well underway through the Information Technology 21st Century (IT-21) initiatives. The one glaring area which was demanding a great deal of time for shipboard supply personnel, and was not getting much attention by the Navy logistics leadership, was in the data acquisition point in the system. Thus, for logistics, material tagging technology in support of more efficient receipt and inventory actions needed to be investigated.

A review of commercial practices using Electronic Resource Planning (ERP) tools, and tracking technology to improve logistics system accuracy and throughput revealed that a new technology known as Radio Frequency Identification Device (RFID) tags had just recently matured to the point where it could provide a viable solution. There are a wide variety of products available from an ever-expanding vendor base, and these products are providing very reliable performance in logistics applications, at reasonable cost. To date, commercial applications of the technology have been for baggage, parcel, pallet, and container tracking. In addition warehouse management systems and retail electronic pricing concepts are also gaining an ever-increasing level of use. The question is whether this technology can be applied in a cost-effective manner to improve upon the shipboard logistics system.

This thesis identifies potential uses and risks of employing RFID aboard ships. In addition, it lays out a conceptual approach toward developing a notional, hybrid, barcode/RFID Automated Material Handling System (AMSH) for both platforms. The physical characteristics of the shipboard logistics system drive the specific product mix of tags, thus the recommended solution for the aircraft carrier is substantially different than that provided for the submarine.

In conclusion, RFID tagging technology provides a logical next step toward a more automated logistics system for the fleet. There are vast commercial applications that enable complex interconnected logistics systems to operate at improved efficiency and this provides an impetus for potential military applications for the technology and the current cost reductions and product capability improvements can be expected to continue. All of the Navy's ship design teams could benefit from investigating how this technology may be applied toward their manning and lifecycle cost reduction efforts. Such analysis would help to better define their platform's logistics flows, both physically and electronically, early enough in the design process to permit cost effective posturing for the insertion of the IT solutions when risk and cost assessments show a payoff. The technology is here, and it is now time for innovative design engineers to conduct pilot testing, and for the budget managers to conduct Business Case Analysis (BCA), similar to that provided for the Operating Space Items (OSI), to quantify the potential benefit of RFID onboard U.S. Naval warships.

Henry S. Marcus:	Professor of Marine Systems, NAVSEA Professor of Ship Acquisition	Thesis Advisor
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This thesis is dedicated to my loved ones,
Who make my life complete…
Karen, Amber, Christopher, and Jordan

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1 Introduction/ Acknowledgments

This thesis analyzes the material flows, manpower usage, and the administrative and technical interface needs employed in the logistics systems onboard aircraft carriers and submarines to determine where Information Technology (IT) can be applied to reduce lifecycle costs and manning demands. It begins with a summary of the motivation for research. It then provides goals and methodology of this research followed by a detailed discussion of Navy logistic system requirements and future vision. This research identified shortfalls in today's shipboard logistics system, of which one item was selected for detailed analysis. Specifically, the use of IT in logistics material tracking through the employment of Radio Frequency Identification Device (RFID) tags was analyzed. This thesis provides a technical overview of this technology, and a BCA for its application toward OSI material. Furthermore, it offers a number of additional applications of the technology that could further enhance the aircraft carrier and submarine logistics and maintenance processes. Whereas RFID tagging has matured to the point where it is offering reliable and cost effective solutions in the commercial sector, it must be recognized that field testing and more complete cost benefit analysis will be required to properly confirm its true worth as a lifecycle cost saver onboard warships.

2 Motivation for Research

There is an adage "When it comes to war, amateurs think weapons, professionals think logistics". Personal operational experience of having served aboard three 688 class nuclear submarines, combined with a review of current ship design processes indicate that support of logistics is largely treated as an afterthought. Lifecycle cost reductions, reduced manning, and a "Focused Logistics" posture as described in Joint Vision 2010 must be designed into our ships, but today it is only key warfighting performance characteristics of the ship that get due attention. This results in the late stage assignment of left over spaces for storerooms, and from a traffic flow management standpoint, the logistic support operational profile is not given sufficient consideration either. This leads to tremendous inefficiencies for the logistics management onboard the platform, and indirectly generates tremendous penalties in the O&S cost of the ship, and O&S costs are the bulk of the Total Ownership Cost (TOC) of a ship over its life.

This thesis will specifically identify some of the shortfalls in today's shipboard logistics system, and recommend an IT solution to one of the more vexing problems in the area of materiel tracking. This issue is intriguing; it permits a total system approach using IT toward ship design, production, and lifecycle support functions, and appears to offer opportunistic timing relative to a number of new ship design programs. This research is of value to the Navy as it fills in a gap in the ability to quantify the impact of technological insertion as it affects one of the most important aspects of TOC. Furthermore, it serves as a catalyst to study other innovative IT solutions to make a more capable and cost effective fleet for the future.

2.1 Thesis Goal and Methodology

It is understood that technology alone cannot solve all of the issues associated with the migration of today's logistics system into a "Focused Logistics" system for the 21st century. However, potential IT solutions do exist, and are not considered due to outdated

or unresponsive procedural mandates in effect today. Thus, the goal of this study was to take a broad, "clean-sheet-of-paper" approach toward identifying how a technology insertion in the area of IT can be applied to the shipboard logistics system to aid in lifecycle cost and manning reductions for our warships.

The methodology employed in this research is to baseline the existing logistics systems employed on the aircraft carrier and submarine, as well as the shore to ship interface between the Navy's supply system and ships, to identify current issues and initiatives. The next step was to select an issue, research potential IT solutions available in the commercial sector, and to recommend a notional system for use onboard the carrier and submarine.

- <u>Current Issues and Initiatives</u>: Baselining the existing Navy-wide and shipboard logistics systems served as a means to characterize system level material flows, both physically and administratively, and provided a means of identifying current issues and initiatives. This research consisted of a comprehensive Internet search, ship, shipyard, and Navy lab visits, as well as numerous discussions with logistics personnel across the Navy.
- <u>Interface requirements</u>: Since the goal of the research was to identify solutions for the ship, the interface between the ship and the shore-side infrastructure needed to be thoroughly defined and clearly understood such that recommendations put forth from this research could be inserted onboard the ship while at the same time permitting it to function within an unchanged Navy logistics umbrella.
- <u>Select an issue for in-depth analysis</u>: Once today's shipboard issues were identified, and an understanding of current initiatives pursuing solutions to these problems were understood, the task of this research was to identify the gaps which could be potentially filled through the technology insertion of IT. It is apparent that the computer network backbone for an electronic logistics data stream is getting sufficient attention today with the Naval Command Tactical Support Systems (NCTSS) migration plan, but very little effort is being expended at the front end, material level, data acquisition node. This served as a focusing point for the research, and ultimately a detailed analysis of material tagging.

- Commercial solutions: Recognizing that the commercial sector is also engaged in Integrated Supply Chain Management (ISCM) migration, and that the current trend in DoD is to employ proven commercial practices to improve business practices, an in-depth analysis of commercial trends became a necessary element of this research. This study revealed that Radio Frequency Identification Device (RFID) technology has matured to the point where it is being employed in certain logistics applications across a myriad of industries with great success. The issue then became how to apply this technology to the Navy shipboard scenario.
- Technical issues associated with fielding an RFID system onboard Navy ships: An obvious concern with applying RFID tagging methods onboard ships is that it is a harsh environment, both physically and from an RF energy interference perspective, and that would present a real technical difficulty. This prompted an in-depth technical analysis to determine if there was any viability for these devices shipboard. The question was whether RFID had ever been successfully employed for military application. This search identified that one program, namely the Total Asset Visibility (TAV) program for the Marines under the direction of the Naval Facilities Engineering Support Center (NFESC) Port Hueneme, that has employed the technology. A couple of other programs are just now pursuing RFID solutions to address their lifecycle issues were also identified.
- Cultural and organization changes necessary to obtain the full benefit of IT insertion: It is clear that the underlying Enterprise Resource Planning (ERP) system of a company must mirror the organizational and cultural context of the business. Thus, for the IT solutions recommended in this thesis to achieve their full potential benefit, some Navy and DoD-wide logistics paradigms, may need to be adjusted. For instance, a "one-size shoe fits all" solution is highly unlikely as is an "all-at-once" implementation scheme. At the same time, however, a phased in implementation plan must be supported by an agile infrastructure.

3 DoD Requirements

This section identifies DoD mandates pertinent to logistics, and highlights the push toward a TOC focused mindset. It also provides a brief summary of observations from shipboard and shipyard site visits, and general trends in the commercial sector to highlight the importance of improving efficiency in the integrated supply chain process with an emphasis on materiel tracking issues.

DoD Regulation 4140.1-R, DoD Material Management Regulation (1993), the Defense Asset Visibility Plan (1995), the DoD Automation Technology Implementation Plan (1997), and the DoD Logistics Strategic Plan (1998) in support of the Joint Vision 2010 (JV 2010) "Focused Logistics" pillar are providing a framework for change. In a similar fashion the Navy's 21st Century Shore Support Infrastructure Vision and Strategic Plan stresses the need to effectively employ Information Technology (IT) to make efficiency gains while at the same time improving inventory validity. In addition, the Federal Acquisiton Streamlining Act (FASA), the Federal Acquisition Reform Act (FARA), and DoD Directive 5000.1 (March 15,1996) are stressing the importance of incorporating proven commercial business practices into DoD processes.

All of this guidance boils down to the task of doing more with less in a more open, commercially based manner. In logistics this begs for highly reliable solutions which can meet the ever-quickening logistic support needs of the fleet. In many instances, the solution for reduced lifecycle cost and manning reductions will rest upon effective insertion of IT for automation. For instance, the CVX program has a mandated 25% overall reduction in manning and Operation and Support (O&S) costs, and the Virginia Class SSN has similar pressure to reduce its lifecycle costs. It is assumed Commercial Off-the-Shelf (COTS), "open" IT system solutions, that can be upgraded in a cost-effective manner will be the product of choice to meet these goals.

As in all aspects of a ship's design, the bulk of the TOC of a ship is determined at the very early stages of the ship design process. Ideally the insertion of this technology should be at the feasibility design of a new platform, allowing it to migrate through the production phase and subsequently to enable hand off to a supportable logistics system for the crew to manage over the ship's life. During feasibility design is where the logistics scheme and material tracking methodology should optimally be determined. This includes the layout of service spaces on the platform such as galleys and berthing areas, as well as the logical positioning of storerooms and food storage areas to support efficient operations at sea. The methodology must also define how the material will be stowed, and how it will be tagged and entered into the inventory management databases. Finally, the interface between shore and ship, the specific loading methods, physical flow paths and receipt methods must be designed into the system to permit maximum velocity of material flow in a safe and highly accurate manner.

3.1 General Observations

Today's inventory and receipt processes are still largely manual, labor-intensive actions that are prone to transcription errors. When inventory validity problems are identified, the reconciliation process is also very time consuming. The process is further complicated by the fact that there is no consistent material-tracking scheme used across the entire logistics system. UPC symbols are present on food items, and some bar coding is provided on general supplies but in many instances packages have multiple bar codes used by different layers within the supply chain. Thus, the current receipt and inventorying processes carried out onboard the aircraft carrier and submarine are cumbersome, labor intensive endeavors which must be improved upon to support lifecycle cost and potential manning reductions. The use of RFID and automated material tracking schemes, can provide a means to reduce manning and improve material tracking.

Large lifecycle cost reductions resulting from the implementation of RFID are likely in a number of applications, but only modest manning reduction are probable since a large

amount of the manpower expenditure for logistics movements and administrative support are provided by non-supply department personnel on warships today. The working party concept for stores loads, the concurrent use of supply department and divisional representatives for material receipt actions, and the lost time associated with tracking down manual transcription errors in the piles of paperwork obscures the real costs associated with employing today's shipboard logistics system. Furthermore, the supply department personnel burdened with making today's cumbersome system work have been drawn away from identifying and implementing innovative solutions that may further enhance the overall logistics process to permit them to expend their efforts on more productive tasks.

3.1.1 General Shipboard observations

Observations made during a site visit onboard the Harry S. Truman (CVN-75) illustrate the potential gains associated with elevating shipboard personnel from production line tasks to more productive endeavors much like the insertion of IT for material tracking can do for material receipt and inventory tasks by logistics personnel.

The Food Service Officer of CVN-75, CW04 Cole, employed a self-serve food line method to permit the crew to serve themselves. His observation, and my assessment having observed the noon meal process, clearly indicated enhanced crew morale associated with permitting the individual sailors to determine what food was being placed on their plate. In addition, it was also clear that this permitted CW04 Cole's galley watch captains to reassign their junior people toward apprenticeship roles under the lead cooks, and have the mid-level supervisors assume a tactical role of identifying and fixing flow problems in the overall mess operations. By reassigning the junior personnel to an apprenticeship task their qualifications, in-rate competence and overall self worth relative toward being a contributing member of the crew raised their morale, reduced qualification time for new personnel. Those changes enhanced watchbill flexibility, and set the entire tone for galley operations on the Truman. This was then transmitted to the entire crew in a morale enhancing manner which is hard to quantify; however, but the

point being made is that employing innovative solutions to enhance the material handling processes onboard a warship may offer collateral gains in entirely different aspects of the ship's performance. Thus, it is important to capture the total system benefit derived from organization change as well as technology insertion when conducting cost benefit analysis.

In the case of shipboard logistics it is hard to quantify the true manpower expenditures to handle and track logistics material, and perhaps even more difficult to assess the lost opportunity cost associated with tying logistics personnel to manual receipt and inventorying methods rather than performing higher level tasks. Thus, when one considers the large up-front cost associated with the insertion of technology designed to reduce overall lifecycle cost or manning for the logistics function, it will be very difficult to justify that expenditure in a Business Case Analysis (BCA) without a great deal of supporting data. This data must provide a clear understanding of what specific tasks take most of the sailors' time today, and must determine where organization changes alone, technology changes alone, or some mix of organizational and technological solution can cost effectively enhance total system performance.

Based on the site visit to USS Truman, one example is providing a paperless Storeroom Item (SRI) issue control capability at the interface between the logistics personnel and the rest of the ship's would increase material velocity and minimize transcription errors. This could be achieved by providing a logistics management computer terminal and an interfacing smart card reader with an electronic signature interface device at each storeroom to properly and accurately make the accountability transfer between the supply department and an individual in one of the other divisions on the ship. The application of tagging technology on the material could further permit an automatic debit of material as the item is moved through an RFID reader at the storeroom access point. A smart card swipe to gain access to the storeroom and an automated inventory scheme at the storeroom level would increase material velocity, improve inventory validity, elevate supply personnel from the production task of issuing to a more broadly focused task of optimizing the overall ship's logistics system at large. The net result would be a

paperless material transfer process that could provide real time inventory status in a far less cumbersome way. What are the cost gains of providing this capability? What is the collateral performance improvement associated with increasing material velocity? These questions will all fall into a subjective quantification process embedded in the BCA.

3.1.2 General Shipyard/Manufacturing Industry Observations

In the area of production control, the shipbuilding industry is looking into methodologies, which can improve the detailed planning and management of material, labor, facilities and tooling. One example is the insertion of a material-tracking program known as Real Time Outfitting Management Information System (ROMIS). This product is a joint effort being pursued by various SUPSHIP and associated shipbuilder offices to enhance the flow of materials in support of construction and outfitting of new construction ships. This system begins with a single material receipt process that provides barcode tracking and a common, network-connected database for material management. This system is being enhanced to include financials, and interface issues to permit a more direct download into the Shipboard Non-tactical Application Programs (SNAP) in the future.

3.1.3 Commercial Implementations

In addition, this thesis research identified cost saving methodologies/technologies being employed in other industries to include the use of standardized piece/parts, computerized control and tracking of interim parts and products, automated part markings, and Just-In-Time (JIT) practices.

The integration of the vendor base has also proven to be effective for manufacturing companies such as Boeing, and is also likely to be applicable for the Navy design and ship production processes as well. This concept requires the establishment of solid business relationships with vendors while at the same time, in the case of the Navy, adhering to all government procurement regulations, implementing electronic data exchange protocols, and changing the design and production processes themselves.

Boeing pursued a Common Object Request Brokerage Account (CORBA) Interface Definition Language (IDL) scheme to connect the myriad of vendor and proprietary computer applications together in support of data exchange. They also worked the technology application and the organizational element of the process together to ensure that the business practices of the Boeing-industry vendor teams and the IT infrastructure supported the same business model. This effort required tremendous effort and a large expenditure of capital, but it was a success. Similar efforts have been employed in other industries as well.

An automobile industry analysis by the Industrial Technology Institute (ITI) stated that efficiency and cost gains could be realized by focusing on[1]:

- Growing supplier networks,
- Creating extended enterprises (fully complemented with suppliers),
- Implementing integrated supply chain business processes.

The ITI study indicated that an anticipated \$1.1 billion, or \$71.17 per car savings is likely. Gains associated with supplier networks could be expected to return a 10% reduction in supply chain management costs, 15% improvement in on-time delivery, 30% reduction in order fulfillment time, and 10% improvement in overall productivity.

There are a number of initiatives underway to pull these industry lessons learned into the Navy/shipbuilder business process with the goal of gaining cost savings across a broad scope of projects through the application of research monies to a specific task. The MARITECH ASE "Electronic Commerce and Advanced Design Technologies" initiative in the Systems Technology pillar of their effort is working to define and provide an industry process standard/model for improved supply-chain integration as well. Another area getting attention is in Materiel Technology to create a marine equipment database covering ship-type equipment, that are pre-approved by classification societies and

[1] MARITECH ASE paper, Sourcing and Supplier Integration Section.

regulatory bodies for use. If such a list can be generated, then it would provide a component hotlist, which could be accessed for design, production line substitutions, and fed into the lifecycle support process for Navy ships. The point of mentioning these items is to simply highlight the fact that all facets of a Navy ship's life can be integrated, and solutions to any one phase of the life can have a profoundly positive or negative impact on the other phases. Effort spent by one program in the design phase may have an impact on the lifecycle support of an entirely different platform, and it is from these ties that compounding cost and manpower savings can be generated.

4 Baselining the Process

The first step in the design process is to define the system and its interfaces to the Navy-wide supply system. This research involved an extensive subject search using the Internet, and by establishing a Point of Contact (POC) list of subject experts, provided in Section 9.3. The next step in the process is to identify where the greatest potential gains could be made through the insertion of IT.

4.1 Definition

Logistics is the science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, those aspects of military operations which deal with[2]:

- Design & development, acquisition, storage, movement, distribution, maintenance, evacuation, & disposition of materiel;
- Movement, evacuation, & hospitalization of personnel;
- Acquisition or construction, maintenance, operation, & disposition of facilities;
- Acquisition or furnishing of services.

This study will address the management of the 1st element of the above definition, namely the movement and tracking of material onboard U.S. warships.

4.2 Background

Admiral Reason, Commander in Chief (CINC), U.S. Atlantic Fleet in a paper titled "Sailing New Seas" highlighted the fact that the world has clearly moved into the

[2] Joint Pub 1-02, Department of Defense Dictionary of Military and Associated Terms (1 December 1989).

"Information Age". He stated that this is a rapid transition, and that hard, objectively measured, incontrovertible data is key. He pointed out that the transformation in commerce, finance, social relations, and the armed forces is accelerating. As the technology and world evolves, it is desirable to maintain agility through decentralized leadership supported by nets of distributed data systems, expert systems and redundant communications. This will support the driving need for reduced warship manning, and will eventually lend itself to determining how best to provide for national defense itself.

Quickness will be the measuring stick, and flexibility will be a must. Well-trained, sharply focused and mutually supporting personnel and infrastructure in a flat agile organization is essential to get there. Admiral Reason pointed out that lessons learned from successful commercial business in a number of areas would be helpful. Those areas, which relate to the logistics focus of this thesis include[3]:

- Networking and information management,
- Supplier integration,
- Data collection and analysis,
- Food services, and
- Dynamic incorporation of new and advanced technologies.

He stated that a key is to provide more and better information to the lowest level that has a directly involved decision-maker with the scope and training to understand and digest the information fully. Then at this optimal level, employ the data, make decisions and provide feedback up the chain of command.

The critical measure of expense is the life cycle cost per unit of combat effectiveness. This can be applied at the unit level or at a force level. In optimizing the metric it is clear to see that both technology insertion and organizational evolution is needed. In line with this concept is the establishment of durable logistics support chains from the Navy

3 Admiral Reason, Commander in Chief (CINC), Atlantic Fleet, Sailing New Seas, Spring 1998.

regional infrastructure. COMNAVUSA will be challenged with evaluating emerging "Information Age" technology to improve the organization and systems, and will be charged with measuring and monitoring fleet readiness. Squadron and group personnel do the monitoring and assessment task today. Permitting a migration of this function to an organizational level will do a great deal to maintain standardization, interoperability and permit a better transfer of best practices.

Finally, the logistics arm of fleet operations will be directed by the Fleet Combat Support Command under which a 2 star admiral will serve as the director of Logistics Support. This function reports to COMNAVUSA as do 5 other functional support commanders and 8 Naval regional commanders to provide a clear organizational framework for infrastructure support. Thus, we see in this quick overview that the Navy organization is posturing itself to incorporate proven commercial business practices, and that an emphasis on time, as the scarce resource to evaluate system and organizational performance, supports the incorporation of automation. This entire effort hopes to institutionalize the need to continuously record and analyze man-hour expenditures by individual, function, product or service, and customer or objective. This supports the concept of an automated Material Handling Information Management System (MHIMS) onboard the aircraft carrier and submarine.

4.2.1 DoD and DON Automated Identification Technology (AIT) Vision

The DoD is attempting to determine "the proper mix of technologies that allow users to efficiently and effectively capture, aggregate, and transfer data and information, and integrate with logistics AISs, using the optimum technology for their particular application. AIT will facilitate data collection and flow to all AISs to better achieve full Total Asset Visibility, enhance and streamline business processes and warfighting."[4]

The Navy AIT Program Office Vision is to "deliver AIT applications which provide

[4] Navy Automated Identification technology Homepage, http://www.navy-edi.com/nav-ec/projects.html#top.

accurate, timely and usable information for Total Asset Visibility through the most efficient use of AIT to continuously improve Navy-wide logistics processes, enhance operating force readiness, and reduce the cost of logistics."[5] As can be seen by these policy statements, there is a big push for automation as the only viable means to meet the focused logistics requirements of the warfighter.

4.2.2 Joint Vision 2010 (JV 2010) Focused Logistics Guidance

JV 2010 states that focused logistics will enable reduced inventories, infrastructure and response times, thereby providing more efficient, effective and integrated support to the warfighter. This requires the fusion of information and the integration of business processes to achieve functional integration within an interoperable information environment. Information technologies offer ways to streamline the logistics requirements of both Navy and joint forces, moving beyond the cumbersome logistics tail needed to supply immediate support to forces ashore today[6]. Logistics aspects are being implemented using IT within the NCTSS[7].

4.2.3 Naval Command Tactical Support System (NCTSS)

The purpose of the NCTSS effort is to provide full range mission support for computer hardware and software in support of the management of information, personnel, material, and funds to maintain and operate ships, submarines, and aircraft. It is to provide effective, efficient management of information resources, through use of standardized hardware compatible with that used for tactical applications. Four basic components supporting NCTSS applications are:

- Shipboard Non-tactical Automated Data Processing (ADP) Program (SNAP),
- Naval Aviation Logistics Command Management Information System (NALCOMIS),

[5] Ibid.
[6] Jay L. Johnson, "The Navy in 2010: A Joint Vision", winter 1996-7 JFQ, page 17.
[7] C4ISR Master Plans, Aircraft Carrier, page 4-7.2.

- Advanced Technical Information System (ATIS),
- Maintenance Resource Management System (MRMS).

These systems are being pursued Navy-wide to support the logistics flow of material in support of operations and maintenance. The interface issues associated with transferring data between these applications, and in tying in these databases to future application programs is getting good program office support. Thus, no specific deficiencies exist here.

4.2.3.1 SNAP

The SNAP system is used to track equipment status, and to requisition replacement parts for shipboard maintenance actions as necessary. Furthermore this PC-based, Local Area Network (LAN) connected system, generates all required reports, and is capable of electronically submitting data via phone line or message traffic into the Navy supply system. Reports of inventory validity and supply department management actions are recorded in the system databanks and this information is easily transferred to the Squadron or Group Supply personnel for fleet wide tracking. This system is being upgraded across all platforms under the NCTSS initiative to create a fully interoperable function. No specific issues exist here.

4.2.3.2 NALCOMIS

NALCOMIS provides a standardized aircraft related equipment maintenance system for seagoing and shore based support facilities. This system supports the generation and tracking of work packages and maintenance availability planning for this gear. This system provides item visibility throughout the maintenance process (both onboard the ship and throughout the Navy supply system). This capability has proven to greatly reduce the loss of very expensive Aircraft Depot Level Repairable (ADLR) material, and

has enhanced the overall operational performance of the carrier fleet. It turns out that a large portion of this equipment is passed from one carrier to the next depending upon where it is in its operational cycle. Furthermore, since the ADLR material directly supports the attached air wing, and because the support of a given airwing is unique due to highly varied configurations of aircraft in the force, it is very important to have the correct material on the correct platform.

It should also be pointed out that the tracking of the ADLR material is being enhanced through the use of Contact Memory Devices (CMDs) which are touch read integrated circuits. The goal behind the application of this technology is to put the logbook data, configuration specifications and run hours, onto the actual piece itself to alleviate the unnecessary cost burden of excess maintenance when a logbook is lost. In addition, it is expected that the incorporation of this more automated tracking technology will also prevent the manual transcription errors that are causing a huge loss of material and the wastage of numerous man-hours to correct.

In conclusion, NALCOMIS is a stand-alone system which should have an interface to SUADPS to permit this leg of the aircraft carrier logistics process to be somewhat integrated with the rest of the system. It is understood that the integrity of the NALCOMIS database must remain in-tact, but the benefits of permitting a one-stop management summary capability would be beneficial.

4.2.3.3 ATIS

ATIS is a system, which houses CD-ROM ship's drawings and component technical manuals. Maintenance personnel access this system as they plan for maintenance actions and part ordering to repair failed components or to complete planned maintenance efforts. This system does permit data transfer into the SNAP system, and can be accessed in generating NALCOMIS or MRMS maintenance packages as well.

4.2.3.4 MRMS

MRMS is a system used by shore based maintenance commands to generate work packages and plan for ship availabilities. This system provides for authorization reviews, parts and scheduling tracking, and resource management for the shore-based maintenance commands. This system is similar to the NALCOMIS system described above. One comment about maintenance package support applications is that each shipbuilder has his own, and that interfaces between these systems are not yet in place. In fact as will be described in the Northeast Regional Maintenance Coordinator Site Visit, Section 4.6, the effort to interface these systems has all but faded. This will demand a more robust interface capability through some sort of common language approach such as the CORBA IDL standards or the Microsoft Com link protocol. The bottom line is that a design to lifecycle ship project will require some sort of interface across these varied systems, and that this is one hard issue that still remains.

NCTSS furthermore employs a common software architecture and Common Operating Environment (COE) to support compatible software applications. Some force sustainment mission needs that NCTSS provides include[8]:

- The ability to effectively support the management of the full range of onboard maintenance needs,
- Ability to exchange unclassified data with own ship's tactical systems and shore mission support infrastructure in a timely, accurate, complete manner,
- To provide flexible systems with sufficient accessibility, capacity and speed to effectively support local decision analysis,
- To provide improved automation capabilities for deployable units and shore support sites,
- To provide sufficient capacity to accommodate improvements to mission support Information Resource Management (IRM).

[8] Ibid.

Meeting these NCTSS mission needs, the tactical commander will be provided with improved equipment supportability and maintainability, and the associated enhancement in material condition and combat readiness.

An open system architecture as developed by the Joint Military Command Information System (JMCIS) Afloat Program will be used to ensure interoperability with other units. It also supports Paperless Ship concepts, Continuous Acquisition and Life Cycle Support (CALS) initiatives. The Primary Benefits of NCTSS to the Fleet and the Navy are[9]:

- It provides the tactical support management information portion of an integrated C4ISR system in support of mission readiness,
- It establishes a single integrated ship and aviation maintenance, supply, financial, medical, and related administrative system, and provides readiness and sustainability information for operational decision-making,
- Fosters a common integrated logistics support infrastructure with tactical systems through use of a "common engine" and COE,
- Improves the ability to incorporate new or changed functionality,
- Reduces the number of hardware and software configurations,
- Increases communications capability among systems and subsystems.

It will do all of this by following a Navywide evolution toward a common Global Communication Support System (GCCS) to generate a common operating environment linked into a global network. Throughout the migration path, the Business Process Improvement (BPI) method will be used to rethink and redesign business processes to achieve dramatic improvements in critical measures of performance such as cost, quality, service, maintainability, and speed. It will be an incremental process starting with identification of functions and applications in five legacy systems resident on the carrier today. Namely: Snap I, Snap II, NALCOMIS IMA, NALCOMIS OMA, and MRMS[10].

9 Ibid., page 4-7.8.
10 Ibid., page 4-7.9.

These functions and applications will be grouped into four categories: supply/financial, ship's maintenance, aircraft maintenance, and personnel/administrative.

The first step in developing the NTCSS functional architecture will be to optimize the functions and applications previously provided by the legacy systems without loss of functionality. The entire package will be integrated into a common operating system and will be thoroughly tested and optimized. The optimization effort has three main goals[11]:

- Provide the user with a good Graphical User Interface (GUI),
- Provide a Relational Database Management System (RDBMS) providing improved data management and "ad hoc" data access via Structured Query Language (SQL),
- Provide a COE, which provides users, administrators and programmers a standard console.

The final step in the functional architecture development will be to provide the unit commander with an efficient, flexible, integrated view of all information relevant to command and control of the unit. This will require logistics battle management and interface with JMCIS Afloat. It will need to consider the [12]:

- ability to support data set retrievals/calls by applications in JMCIS Afloat against data bases in NTCSS,
- ability to provide information rollups and views which describe material and personnel readiness and logistics with respect to projected operational mission profiles to support what-if analysis,
- ability to view readiness and sustainability information globally at a theater or force-wide level.

[11] Ibid., page 4-7-9.

[12] Ibid.

The end product will be a flexible, comprehensive, integrated information support system for the warfighter, and it is bound to result in both manning and cost reductions while at the same time improving force effectiveness. This is the panacea that is needed to do more with less in the tight fiscal conditions of today.

4.2.4 Defense Information Infrastructure (DII)

The NCTSS effort is similarly consistent with an overarching initiative known as Defense Information Infrastructure (DII). The goal of this effort is to revolutionize Information exchange Defense-wide, strengthen the application of computing, communications, and information management capabilities to meet the DoD mission, significantly reduce the IT burdens on individual units, and enable a worldwide sharing forum from Personal Computer (PC) to PC via the Internet.

DII is similarly consistent with higher level efforts for a National Information Infrastructure (NII), and Global Information Infrastructure (GII) framework, which are driving toward a common, interoperable posture for electronic communications in general. One of the biggest drivers for this standardization is the rapid growth in Electronic Commerce being fueled by the proliferation of an Internet connected consumer base.

4.2.5 Technical Architecture Framework for Information Management (TAFIM)

TAFIM is mandated under the DoD 5000.1 guidance, and promotes the integration of Department of Defense Information systems. It provides guidance for the evolution of the DoD technical infrastructure, defining the services, standards, and design concepts, components and configurations that can be used to guide the development of technical architectures that meet specific mission requirements.

Today the information system infrastructure consists of largely stovepiped, single-purpose, and inflexible systems that are costly to maintain. This is being addressed under

a migration plan toward open systems. The DoD vision emphasizes integration, interoperability, flexibility, and efficiency through the development of a common, multi-purpose, standards-based technical infrastructure. A Technical Reference Model (TRM) is being pursued to bring commonality and standardization to the infrastructure. TRM addresses services and standards necessary to implement a common system for design, acquisition, and reuse.

It must be pointed out that TAFIM does not provide specific architecture, but rather it provides the services, standards, design concepts, components, and configurations that can be used to guide the development of technical architectures to meet mission needs. It promotes interoperability, portability, and scalability. The data architecture underlying this approach supports standard data elements, data integrity, data availability, shared databases, and the separation of applications and data.

The TAFIM initiative is fully committed to implementing an Open Systems Environment (OSE). This will permit the information systems to be developed, operated, and maintained independent of application-specific solutions or vendor products. A DoD Goal Security Architecture (DGSA) is focusing effort toward a common, integrated policy to ensure integrity, confidentiality, availability, and authenticity of enterprise databases and resources.

The vision is to establish shared databases that are centrally managed and controlled to meet the needs of the entire DoD. Data will be accessed over a common-user global network riding on a Defense Information System Network (DISN). Data will be input through a variety of flexible and responsive devices from the office to the battlefield. Electronic capture and display of information will move toward a paperless system. Currency, reliability, and responsiveness are being greatly improved, errors avoided, and the integrity and security of the DoD data will be assured by new procedures and automation. [13]

[13] TAFIM Volume 1, http://www-library.itsi.disa.mil:80/tafim/tafim3.0/pages/Volume1/v1.htm#vdit, Appendix C.

A Defense Data Dictionary System (DDS) provides a DoD repository to receive, store, support access to, and manage standard data definitions, data formats, usage, and structures (e.g., architectures, subject area models, and other data model products).[14]

Finally, the TAFIM initiative is following a total systems approach to achieve an optimum balance of all system elements. It is transforming operational needs into descriptions of system parameters and integrating those parameters to optimize the overall system effectiveness. It has implemented metrics for evaluating both hardware and software system attributes. A few of these metrics include[15]:

- Response time
- Throughput
- Workload Specs
- Resource Usage
- Transaction Frequency
- Capacity

A key factor in pursuing these metrics is to ensure that life cycle demands can be met, and that reuse of product is possible.

4.2.6 National Science Board Investigation Findings

The National Science Board panel stated that the Navy spent 30 percent of its budget (22 billion in 1995) to manage and move material in support of U.S. naval forces at sea; from the sea and over the shore; and the design and maintenance of weapon systems to maximize their operational readiness.[16] The study pointed out that this condition offers a target area for improvement.

[14] TAFIM Volume 1, http://www-library.itsi.disa.mil:80/tafim/tafim3.0/pages/Volume3/v1.htm#vdit, Section 3.6.2.
[15] Ibid., Section 3.20.4.
[16] "Technology for the United States Navy and Marine Corps, 2000-2035, Volume 8: Logistics, National Academy of Sciences", 1997, page 1.

A quick review of current logistics assets reveals that many of the existing logistics ships are reaching the end of their useful life, and that demands placed on replacement assets will require greater flexibility, and effectiveness to meet the pace of battle in the 21st century. Thus, it is an opportunistic time to design the replacement ships both combat units and supporting logistics assets to reduce overall life-cycle costs while at the same time improving battle readiness.

The design of such a system must meet mission requirements while presenting a small footprint ashore. Logistic operations will have to be rapidly planned, tightly controlled, and have precision delivery schemes. Automatic identification and tracking devices will almost certainly be required. This will further require the creation of analytic tools, models, and simulations to anticipate logistic requirements, identify and assess, and select alternative paths through real time monitoring. It is likely that this information flow will be a steady stream of digital data updating files on unit locations, supply status, equipment performance parts availability and shipments as well as many other logistic details. The communication support for this function will be accommodated under the Command, Control, Communications, Computers, Surveillance and Reconnaissance (C4ISR) Master Plan for each platform, and interoperability will be paramount.

From an operational context, offloading or taking on stores can be expected to take place in established ports, using commercial port facilities. Thus, methods used in CONUS and for deployed units should be similar. In addition, the use of a computer based digital database can be expected to support in service monitoring to identify when a component or weapon should be taken out of service, and it may allow system designers to get direct simulation feedback on design matters before the system is fielded. The possibilities are limitless.

A total systems approach toward the design of a system, which thoughtfully employs a combination of embedded sensors, digitization of technical data, telecommunications, and intelligent software into an MHIMS has the potential to generate tremendous efficiency gains for the entire system.

The bottom line is the Operation and Support (O&S) costs of maintaining the fleet today are unaffordable. However, technology is properly positioned to provide real time information management schemes to support operational inventory tracking, and permit an anticipatory logistic posture rather than a time lagged one, and change must occur. To obtain the full potential of this emerging technology, the cultural and organizational aspects of the logistics system will also have to evolve away from a business as usual posture toward a continuous improvement mindset.

IT is likely to offer the greatest positive impact on the logistics system. It should be able to support the planning and controlling of supplies to naval forces, provide logistic command, control and communications needed by Operational Maneuver From the Sea, and maintaining weapon system readiness.[17] Information Technologies that support this are:

- Automated marking and identification technology to alleviate manual input inefficiencies.
- Sensors and intelligent software for monitoring logistic activities.
- Displays and software for assimilating, presenting and making it easier to use the vast quantities of logistics data.
- Modeling and simulation for real-time planning, assessment, and selection of courses of action for logistics movement.
- Distributed collaborative planning, for rapid coordination of re-supply actions.

It should also be pointed out that gains might also be obtained if the logistics system permitted the use of standardized commercial container loading onto warships. If the logistics infrastructure evolved to the point where the configuration of the individual

[17] Ibid. Page 5.

platforms was well understood, then the order of loading into the container and the electronic transmission of Advanced Shipping Notices (ASNs) would provide a quicker handoff with the employment of fewer resources.

This is an important factor in the overall operational effectiveness posture of the combatant because inefficient pierside, or at sea (UNREP/ VERTREP) logistics exchanges hamper flight operations or place limitations on maneuverability or self-defensive capability. In addition, the operational posture of the logistics forces will be reduced by inefficient deliveries because their performance will be judged by their ability to make the correct handoffs in as close to an optimal delivery loop as possible.

4.2.7 Establishment of Defense Reform Initiative Office

Acquisition reform is captured in the DoD Directive 5000.1, and under this umbrella a number of initiatives are underway. One such item was the creation of a new post, the Director of Defense Reform Initiative Office. Admiral Houley, USN (Ret.) has filled that post and has been tasked with a few key goals:

- Re-engineer DoD methods by adopting the best private-sector business practices in defense support activities.
- Consolidate and streamline organizations to remove redundancy and move program management out of corporate headquarters and back to the field.
- Compete many more functions now being performed in-house, which will improve quality, cut costs, and make the Department more responsive.
- Eliminate excess infrastructure.

RADM Houley stated that it is much easier said than done. Furthermore he stated "We have a lot of processes where we march contracts from Office A to Office B, fill out a procurement request, then we go through a long process that nobody wants to hear about. We should be able to do it from a keyboard, with a lot fewer steps and in a lot less

time."[18]

4.2.8 Previously Funded Logistics Support Studies

Recognizing that the logistics flows onboard current aircraft carriers are cumbersome today, the CVX program office initiated shipboard studies for weapon handling/movement and automated material handling. The reports generated from these studies were published in 1998, and they did indicate that there were physical material flow issues as well as IT shortfalls associated with how logistics are handled aboard aircraft carriers. Some highlights are provided in the following sections.

4.2.8.1 The Newport News Shipbuilding, "A CVX Weapons Handling/Movement Study Final Report"

This report stated that personnel reductions are likely if a computerized weapons data management system to track storage inventory was used.[19] In that same study, it was stated that a complete new set of management and communication tools must be developed for this area, and that a tremendous amount of time is currently being consumed in manual planning functions for magazine arrangements, ordinance requirements, underway replenishment operations, buildup operations, and breakout operations. Taking inventory, documenting expenditures, controlling resources, tracking equipment status, tracking elevator status, etc., all lead to inefficiencies. The article suggests that a suite of software tools is needed. In addition they recommend review of Integrated Logistics Support (ILS) initiatives being pursued by NAWC-AS Lakehurst using Contact Memory Devices (CMD) for the tracking of Aircraft Depot Level Repairable (ADLR) material.[20] CMD's are integrated circuit buttons which can store substantial amounts of memory, are very durable in adverse

[18] Rudi Williams, "Sueeess Means Going Out of Business, Houley Says", Program Manager Magazine, November-Deeember 1998, page 22.
[19] Newport News, Weapon System Handling Study
[20] Ibid.

environments such as in the high temperature and vibration environment of an operating aircraft engine, and have a price tag of about $7.00. The introduction of CMD on this material is designed to permit collocation of logbook data with the component to avoid unnecessary maintenance action when the logbook and component get separated or lost. Finally, the Business Case Analysis (BCA) conducted to justify the acquisition costs of fielding CMD technology was far lower than the current $20+ million dollar/year lost material scenario today. Thus, this materiel tagging technology essentially paid for itself overnight.

A Logistics Support Analysis (LSA) is being pursued to develop and define supportability-related design factors and to identify the logistics support resources required for the life of the system. This is further supported by a Logistics Support Analysis record (LSAR) to provide a standardized, automated, data system to document the results of the LSA and provide maintenance planning, supportability and support data and reports. [21]

In their Task One they identified onload and offload, strikedown and strikeup, and retrograde storage and disposal routes and resource needs.

4.2.8.2 Avondale Industries, in their "CVX Automated Material Handling Trade Study"

This report, dated 1 June 1998, stated that Chiquita Banana Company revealed in an interview that standardized packaging is an important factor in the effectiveness of the system. In addition, a logical loading scheme needs to be planned out in advance. It was appropriately pointed out that the interface between ship and shore would need to be modified as well to get any real efficiency gains. They further recommended the initiation of an overarching IPT for all the stakeholders in the logistics process.[22]

[21] Integrated Logistics Support (ILS) Capability at Navy Lakehurst, http://www.lakehurst.navy.mil/techcap_2a.html.

[22] Avondale Industries, "CVX Automated Material Handling Trade Study", 1 June 1998

On a visit to the Systems Modeling company in Sewickley, PA, they found that a product known as ARENA is a one-step, object-based simulation system compatible with MS office. Very flexible, easy to use, and it is used by COMPAQ, UPS, FEDEX, CSC, BOOZ, Allen, Hamilton, Boeing and Arthur Anderson. This system should be evaluated for potential DoD use.

The study further stated that information and packaging technology should soon be available to permit supply points and logistics ships to know enough about the configuration of each ship, its storerooms, strikedown routes, and locations of materiel on board to permit packaging, labeling, and sequencing of deliveries for efficient "warfighter-ready" delivery.

4.2.9 Electronic Commerce

The DoD is moving rapidly to an Internet –based electronic commerce scheme to streamline purchasing. A Navy Electronic Commerce On-Line (NECO) project provides a paperless electronic procurement system. A Fleet Automated Control Tracking System (FACTS) is being developed to improve the oversight of material within the Navy's Advanced Traceability and Control System (ATAC) for in-transit visibility. An EDI Afloat program under the NTCSS program is pushing to tie in the shipboard LAN with shorebased logistics support systems. This system will support the following[23]:

- Retail Operations Management (ROM) which is a system to enable Ships Stores to electronically procure merchandise directly from a vendor; allow DFAS to initiate payment based on an electronic invoice; and allow ships to electronically report receipt to DFAS for use in performing payment reconciliation.
- Automated Non-Standard Requisitioning System (ANSRS) to provide activities with a standardized, automated procedure for processing nonstandard material buys and demand reporting.

[23] Tim Sheppard, Project Manager EDI Afloat, Naval Supply Systems Command, The Facts About FACTS, January 1999.

- Food Service Management (FSM) to permit users to place orders, certify receipt of provisions and authorize payment of dealer invoices using EDI transactions. Information provided from the vendor will be forwarded via EDI and directly uploaded into FSM and this will reduce time demands on food service personnel and improve validity.

The FACTS system consists of three modules (retrograde, shipping and transshipping) that provide managers, supply officers, item managers, and hub personnel with in-transit visibility of retrograde material after it leaves the ship. It uses a bar coded Issue Release/Receipt Document (IRRD) (DD Form 1348-1A). It also sends a shipping notice via the Streamlined Automated Logistics Transmission System (SALTS). In the shipping module the bar code scanning can be assigned to Transportation Control Numbers (TCNs) and generate both Transportation Control and Movement Documents (TCMDs) (DD384s) and shipping labels (DD1387s). In the transshipping module the system is able to pass the information through intermediate hubs without additional data entry. This system has been tested on the USS John F. Kennedy (CV 67) and has performed well.

Another initiative known as the Quality Application and Database Suite (QUADS) is providing a means to electronically support document management. One application of this system is for the Armed Forces Recipe Service (AFRS) system that will permit the tying together of nutritionists from the Recipe Service Committee and permit recipe updates online.[24] This will permit faster change authorizations, and be a positive influence on fleet morale.

In addition a Joint Electronic Commerce Program Office (JECPO) was established on June 5, 1998 to facilitate the transition to electronic commerce, which cuts overhead and contracting costs, eliminates middlemen, and makes DoD more customer-friendly to businesses large and small.[25]

[24] CDR Ronald Roskowski, QUADS and Beyond, http://11192.211.116.35/lintest/jfweb/quads.htm, Jan 1999.

[25] OASD public affairs news release ,"Defense Department Makes Progress with Reform Actions", Program Manager Magazine, November – December 1998, page 28.

JECPO in adopting Best Business Practices of the private sector has mandated the following:[26]

- By January 1, 2000, all aspects of the contracting process for major weapons systems will be paper free.
- By FY 2000, 90 percent of DoD purchases under $2500 will be made using the government-wide IMPAC purchase card (almost half of all purchases).
- DoD will expand the use of electronic catalogs and electronic "shopping malls" to put buying decisions into the hands of the people who need the products.
- Creating paper free systems for weapons support and logistics.
- By July 1, 1998, DoD will discontinue volume printing of all DoD-wide regulations and instructions and will make them available exclusively through the Internet or DC-ROM.
- By January 1, 1999, prime vendor contracts for maintenance, repair, and operating materials will be available at major United States installations.
- Replacing the traditional military "just-in-case" mindset for logistics with the modern business "just-in-time" mindset.

4.2.10 Electronic Mall (E-Mall)

The E-Mall allows DoD customers to search, locate, compare, and order material based upon quality, price and availability. The E-Mall is "point, click, and ship" Internet-based system for locating and ordering commercial items quickly and easily. It streamlines the traditional procurement process-reducing delivery time for commercial items from weeks and months to as quickly as 24 hours. This flexible system can allow the addition of unlimited numbers of commercial electronic catalogs to increase from over four million DLA managed items today and hundreds of thousands of commercial items from vendor catalogs, corporate contracts, and the Navy's information management technology

[26] JECPO Homepage, 5 Feb 1999, page 1

catalog, to potentially limitless items in the near future[27]. Preliminary estimates of tens of millions of dollars annual savings are expected.

4.2.11 IMPAC card

IMPAC card is a commercial VISA card issued to individual offices and organizations for official purchases under $2500. It provides a less costly (up to a 50% reduction in cost) and more efficient (up to 5 times as fast) way for the Department to buy goods and services directly from vendors instead of processing requests through procurement offices.[28] It is estimated that 85% of all purchases under 2500 were made with IMPAC Cards, and that it saved the taxpayers $285 million dollars. In addition, it is anticipated that retail-level inventories will be reduced from $14 billion in FY 96 to $10 billion in FY 2001.[29]

This program has been expanded by Deputy Secretary of Defense John J. Hamre to cover all training costs below $25000, all medical services and non-appropriated payments under $2500, goods and services under $2500 purchased using standard contracting instruments, and all military inter-Departmental purchase requests under $2500.

In the event that RFID tagging is pursued for shipboard use, the items purchased from local vendors by use of the IMPAC card will require a shipboard capability to apply RFID tags to the material prior to loading. This should not be a problem, but it highlights the fact that material arrives aboard ship along many different paths.

4.2.12 Wizardworks initiative

Wizardworks is a Fleet Supply Policy Council-sponsored, Naval Supply Systems Command (NAVSUP)-directed, development group responding to fleet ideas for

[27] JECPO Homepage, 5 Feb 1999, page 5.
[28] Ibid., page 5.
[29] Ibid., page 5

improvements in automated afloat supply management. The technical lead for this effort is SPAWARSYSCEN Chesapeake who maintains centralized management of the developmental effort by:[30]

- Providing life cycle management (LCM)
- Providing contract oversight and coordinated tasking with NAVSUP's fleet Support Division (SUP43)
- Standardization of products
- Configuration management (CM)
- Test and compatibility testing (TCT)
- Standardization of fleet trouble reporting.

The Fitting Out and Supply Support Assistance Center (FOSSAC) fleet experts assist in the process.

Some initiatives that have been pursued include an Integrated Bar-code System (IBS) to support receipt processing, quantity inventorying, location auditing, material consolidation and relocating. The general observation is that audits can be conducted more accurately in less time. Future plans for the IBS system include relational Supply (R-Supply) to allow for fleetwide bar code capability for inventory management afloat.

Another effort known as Quick DD Form 1348-1A (Quick – 1) was used to automate the handling paperwork for Hazardous Material (HAZMAT). This system uses the bar code reading technique for data entry.

In addition, a Shipboard Material Automated Reconciliation Tracking System (SMARTS) system has been developed to automate the financial reconciliation process for afloat units. This was supported by the shift from the Fleet Resource Accounting

[30] LCDR Mike Burr, Afloat Supply…Innovation and Technology Working for the Fleet, http://11192.211.116.35/lintest jtweb/afloat.htm, Jan 1999.

Module (FRAM) to the Standard Accounting and Reporting System (STARS) and it meets the requirements of the Summary Filled Order Expenditure Difference Listing (SFOEDL) and Unfilled Order Listing (UOL) reports. The bottom line is that it automates a lot of the financial reporting and analysis functions.

To date, the Wizardworks initiative has not analyzed the viability of RFID tagging as a potential solution for shipboard logistics, but now recent trends in the commercial market, and success stories from DoD applications to date are likely to drive them to an analysis of the technology soon.

4.2.13 Navy Industry Digital Data Exchange Standards Committee (NIDDESC) Initiatives

NIDDESC is an organization attempting to establish Smart Product Model (SMP) protocols which can support data exchange across the entire spectrum of ship design, production and life-cycle support. A few areas that may have particular importance in the life cycle cost area are provided below.

4.2.13.1 Ship Electronics

This standard addresses computers, navigation, radar, communications and other electronic systems, which are embedded in virtually all systems today. It is, therefore, important that shipwide networks, controllers and electronics systems be properly accommodated in ship product model data exchange formats. This then becomes very important for data exchange between shipyards, designers, and life-cycle managers. Similar requirements exist for weapon system models for the interface between ship designers/builders and weapon system designers/manufacturers. There does appear to be a migration to the Microsoft COM interface standard.

4.2.13.2 Ship Parts Library.

A resource model for standard part libraries is also required for the exchange of ship product model data. This can permit the designer to receive Computer Aided Design (CAD) data from vendors, pass such information to shipyard production engineers, and to life cycle maintainers. The goal of this initiative is to provide object standards for:

- CAD model to model exchanges, and to support product model exchanges between vendor parts catalogs, designers' CAD models and shipyard manufacturing systems.
- Parts library information together with the necessary mechanisms and definitions to enable parts library data to be exchanged used and updated. The protocols must be able to exchange data between different computer systems and environments associated throughout the complete life cycle of the ship, including product design, manufacture, utilization, maintenance, and disposal.
- Links to external logistics information databases.

The general goal today is to evolve these systems to a point where they at least have the ability to pass data back and forth. The ultimate goal is to create a seamless interoperability that can permit part ordering, unit readiness, platform configuration management, and fleet level management trend analysis to drive down O&S costs of maintaining the fleet. There are a number of issues associated with this process, and there is a great deal of effort being applied through the regionalization of the force. Regional maintenance staffs are driving toward efficient use of maintenance organizations and in addressing system interface issues. The regional command structure is consolidating the fleet support services and base infrastructures to be more consistent with proven commercial business schemes, and the operational and support commanders are more clearly defining their lines of responsibility to control infrastructure expenditures.

4.3 Site Visits

Site visits were conducted on the Harry S. Truman (CVN-75), Submarine Group Two Supply, Supervisor of Shipbuilding Newport News and Electric Boat, and the Northeast Regional Maintenance Coordinator. The purpose of these site visits was to see, first hand, the current logistics and maintenance processes and to identify weak points which could potentially be addressed through the insertion of IT. The observations from these site visits were subsequently discussed at a meeting held at the Newport News Shipbuilding Innovation Center at which the Supply personnel from USS Nimitz (CVN-68) provided their input. Details of these site visits follow.

4.3.1 Harry S. Truman CVN 75 site visit

To properly baseline an aircraft carriers logistics flows, a site visit was required. The Harry S. Truman (CVN-75) had just completed her post delivery shakedown period, and had experienced, first hand, the limitations of the currently fielded logistics system. The crew had already identified what issues they intended to pursue upgrades on in their upcoming shipyard availability and were more than willing to share their thoughts in support of this research. The physical layout of the storerooms and material flows was presented as the biggest issue, with the desire for more automation in the receipt and inventory tracking functions falling in as another important area for improvement. The physical aspects of the aircraft carrier storerooms have been addressed in a 1998 Newport News Shipbuilding study, and as stated previously this thesis will focus recommendations toward the application of IT for receipt and inventory enhancements. The goals and observations from this trip are presented below.

4.3.1.1 Specific Goals for the site visit

This trip was conducted on 22-23 February, 1999 and was designed to obtain data in the following areas:

- To see how logistics goods are received and loaded both physically and administratively today.
- To identify the number of personnel resources assigned to each task, and to determine where the employment of technology or updated procedural requirements would help.
- To identify how inventory is tracked today, how requisitions for food and logistics material are made today, and to understand what paperwork or reports are needed to support this activity today.
- To visually sight the storerooms used on the carrier to see how material is stowed and to understand the traffic patterns for logistics loading.
- To see what Navy and self-generated systems are used to track the requisitioning of material, and to characterize how much is done manually, and how much is done electronically.
- To identify what interfaces exist between the ship and the Navy supply system to determine where the best location is for tagging the incoming material.
- To get input from the fleet operators on what they like about the current logistics system, where they feel improvements could be made, and to identify what current initiatives are being pursued and what their impression is of them.
- The bottom line is to capture the input from the customer, the logistics support personnel onboard U.S. carriers today, and to incorporate this input in any report generated from the research.

4.3.1.2 Pierside loading

Pierside logistics material is loaded onto 2 of the aircraft elevators on the starboard side of the ship by crane or by use of a conveyor system. The crane loads material by pallet, and the conveyor belt loads material by box or container. Discussions with the ship's Material Officer LTJG Schmidt indicate that that the typical volume of material is on the order of 220 pallets/week, but that this volume is highly dependent upon the ship's specific point in its operational cycle. He further stated that use of the crane requires 6

personnel to meet all safety and handling requirements and that even with the most proficient loading personnel, it requires substantial man-hours. The crane is preferred over the conveyer belt system because the conveyor system is often inoperable. This piece of equipment is owned by the port, and it is maintained by public works. Thus, when it breaks down, it typically takes a long time for repairs to be made.

Once the material is landed on the aircraft elevator, it is transported by hydraulic dollies into the hangar bay and then in the direction of the various storerooms. It turns out that none of the storerooms is at that level of the ship; therefore, the material has to be transferred to one of 12 box-capable conveyor systems, be handled by a mini-crane, or be broken down and manually lowered into the appropriate storerooms. As in the crane operations from the pier to the ship, it takes six men to move material with the mini-crane. Similarly, use of the conveyor systems also takes six personnel of which four have to be petty officers. This poses a tremendous burden on the logistics divisions, and frankly drives them toward manual stores loading schemes with large working parties.

For instance, the bulk and hazardous material storerooms are located below the after area of the hangar bay. To move material into these storerooms requires the lifting of a large deck plate, and the subsequent use of a mini-crane. Material is loaded into the storeroom by pallet, but a 3000 lb. weight limit is imposed on the crane and as such it is often necessary to break down the pallets. The strong recommendation from the Supply Officer, CDR Martin, was to provide an elevator similar to the weapons elevators at that location. It would greatly reduce manpower, improve safety and permit better logistics flow velocity for critical ADLR, DLR, and general consumable material. This recommendation was also strongly supported by CDR McIlravy, SUPPO Nimitz (CVN-68).

Material, which has been ordered to fulfill specific division repair work, is issued to the appropriate workcenter at the aircraft elevator. The method of conducting issue control involves the use of paper chits rather than electronic handoffs. Furthermore, since the material sent to the ship is loaded on pallets at a pre-staging area at the Naval base based

upon its arrival at that facility, there is no sorting of material by division, etc., done prior to loading onto the ship. This requires additional effort by the ship's logistics personnel and slows down the material velocity.

Finally, receipt for the material by the ship from the base supply organization occurs with paper rather than electronic verification. It turns out that a barcode National Stock Identification Number (NSIN) is applied to the paperwork such that it can be scanned into the ship's SNAP system, known as SUDAPS, which is a next generation SNAP program, by a portable barcode scanner on the aircraft elevator.

The ship's logistics personnel feel that the greatest gains can be obtained by providing a ramp from the pier which can support a forklift, pallet-size delivery capability right up to the aircraft elevator. The next biggest gain would come from locating the storerooms closer to this access point, or at least providing a more effective flow to the storerooms. As far as applying material tracking tags is concerned, the method used today is to scan the bar codes on the receipt paperwork into the NALCOMIS and or Shipboard Uniform Automated Data Processing System (SUADPS) databases. This information can then support the printing of barcode labels, which can be affixed to the material after it has been loaded into the appropriate storeroom. Statements from the logistics supervisors indicate that the material databases do a good job of tying the material to its storage location, but that the act of generating the barcode labels takes too much time at that point of the cycle. Another comment was that the interface between NALCOMIS and SUADPS needs to be improved upon.

4.3.1.3 Logistics Personnel Usage

Discussions with the supply department supervisors indicate that a total of 90 men are assigned, and that this is about 30% less than the requirements. This deficit is driven by an overall shortage of personnel in these NEC's Navy wide. CDR Martin pointed out that the CVN supply officers have identified this as the most critical issue at their monthly roundtables.

Given the 90 assigned personnel, the loading is spread across several divisions. The Divisions that impact this study are the S-8 material management division, the S-6 aircraft material management division, and the S-2 food service division. The bulk of material for the ship goes through these divisions. The S-8 division is the largest with about 40 personnel, the S-2 has 18 personnel, the S-6 division has 6 personnel and the remaining persons in the department are spread across other functions.

The S-8 organization is broken down to support the 2 main storerooms, a shipping/receiving function, a pier/elevator support group, and 2 base to ship coordinators.

- As stated above, the pier/elevator group that consists of 8 persons could be substantially unloaded if a better loading method was created.
- The shipping/receiving group could be better supported if material was pallet loaded in a more organized fashion at the base aggregation site and there are potential gains if the material as well as the paperwork were bar-coded prior to arrival. This would avoid the need to generate the tags onboard and subsequently apply the labels at some later time. There is also a potential gain of applying more advanced material tracking devices such as RFID tags to high value items by this group of persons at the receipt location.
- The main storeroom personnel ultimately are responsible to load the material into the proper stowage location and to ensure that all inventories and issue receipt requirements are properly carried out. The layout of the storerooms is very good, and the validity of material to stowage location appeared to be very good. A couple areas where improvements were possible were at the issue point. Currently they require the division to submit a paper chit to draw out a part even though the request for the part had been previously submitted electronically. This process could be fully automated by having the storeroom issue control person call up that record on the NALCOMIS SUADPS system and then having a smart card scan of the recipient's ID card and an electronic signature entry feed into the

entry. This would reduce transcription errors, make the process more efficient, and at a minimum increase the logistics material velocity.

- For the base to ship interface personnel, it is apparent that any specific requirements desired by one platform will be hard to effect at the base logistics site. Thus, it is in this area where organizational or at least high level, base or Navy-wide involvement would be necessary to yield potential gains onboard the ship.

The S-6 division is principally involved with the receipt and issuance functions for aircraft support material. As described above in the S-6 shipping/receiving function, this division must generate and apply bar codes to much of the material they receive as well. In many instances the material they get has no barcode at all, and as such they have established a local cross reference list to tie this material to a given stowage location. For the ADLR items it is clear that use of higher quality tags such as contact memory button devices or Read/Write (R/W) RFID tags could be beneficial. This material is very expensive, is in high demand, and is transferred from ship to shore to repair facility and then back to another ship over and over again. This requires very robust tracking tags that do not degrade in harsh environments. In addition, the storeroom holding this material is very large, the material itself is very heavy and mostly stored on pallets which are hard to get to. This serves as an example where a location tracking scheme or large area broadcast and report application would be useful.

The S-2 Food Service division onboard the Truman has been set up by Mr. Cole to be a highly effective team. His approach is to have one specific person accountable for all food breakouts, and he uses a ship-generated form to ensure that it occurs properly every time. The issue is that 100% validity is a must in this area, and it is important to identify mistakes quickly. The specific method used is as follows:

- Each galley provides a list of materials that it needs for a given meal to the Food Service Officer. These requests are generated from the Food Service

Management (FSM) program by each galley and presented in hardcopy form to the Food Service Officer.

- The Food Service Officer passes these forms off to the stock room breakout person who then manually enters the data from the FSM forms onto a ship generated food item worksheet. This form permits the stock person to identify the total demand of a given item and avoid the need to go back to a given location up to 5 times to support each of the galley.
- Once the form is filled out the stock person goes to the various storerooms and pulls out the material, identifies which galley it should go to and lays it in the passageway. It is then the responsibility of the galley watch captains to send representatives to the stock rooms to physically carry this material to the mess areas.
- The stock person is tasked with taking a physical inventory of the given food item after he has made his breakout and must record that number on his worksheet.
- The worksheet is then entered into a logbook and is bounced against the FSM inventory by the Food Service Officer twice a week. This identifies mistakes, pilferage's, or perhaps fundamental problems in the system.

The method employed by Mr. Cole is nearly foolproof and has proven to be very effective to date. The areas where the process could be improved would be the integration of the 5 different galleys' FSM programs onto a computer network such that the information could then be electronically downloaded onto the ship generated by item form. This would save about 6 hours a day of effort for the stockroom manager. In addition, if scanning devices were applied at the storeroom access points, it would further enhance the inventory accounting, and may permit full reliance if reliability was proven to be as good as the manual method. The material tracking technology for this function could be barcodes, or it could employ higher tech devices such as reusable passive RFID tags. The only issue that would occur here is that a cost-benefit analysis would need to be done to see if the time it takes to employ such a system can provide sufficient payoff to warrant its time. The point here is that it has to be very easy and cheap to apply the tags.

4.3.1.4 Inventory Tracking Methods

As described in the previous section, inventory-tracking methods on CVN 75 are manual and barcode today. The issue with barcode is that the barcode must be tied to an NSIN to properly fit into the requisitioning process. Since the NSIN is a Navy mandate, rather than a standard commercial practice, the options are to impose the requirement on the vendor to apply a special label for Navy deliveries, or to write your own tag.

The main storerooms on the CVN are configured to support easy inventory, and perhaps even walk-by RFID scanning of material. The bulk storeroom is not configured to support this concept today. To do so would require some inventive stowage scheme that permitted use of a maximum amount of space while at the same time permitting walk-by scanning of the material. In addition, one question which would need to be considered is how to differentiate between what material can reasonably be tracked at an item level with an RFID type of scanner, and which must be tracked by some other means.

The frozen and chilled storerooms are frost-free, well stowed to permit easy inventorying and could support anything from manual methods, to barcodes, to RFID tracking tags. This is notably different than what is seen in submarine cold storage areas.

4.3.1.5 Storeroom Locations and Layout

As described above, there are many storerooms on the ship and their location is not optimized for function today. This should be analyzed in depth in the early design stages for CVX. The shelving and stowage racks in the storerooms should also be carefully analyzed. As noted on CVN 75, baseline ship stowage cabinets did not support easy inventory management and the ship had them all pulled out and had modified stows installed. My assessment of the change is that it will better support the management and inventory tracking capability in the storerooms. The size of the storerooms appears to be adequate, and the tie between the material locations and the tracking database appears to

work well. One interesting observation from my site visit is that the Food storerooms do not have any location labels since a single man does all of the breakouts, whereas the material storerooms have bar coded labels for every shelf and item.

4.3.1.6 Level of Automation Employed Today

As stated above, there is a great deal of automation in the process today. The automation can be improved at the issue control points for general material issue, and the use of tracking device scanners at storeroom egress points could be employed to provide a backup or perhaps a more reliable method of tracking inventory. This will require some standardization or at least a well thought out scheme to get all of the material marked prior to loading. A study conducted by Newport News Shipbuilding dated October 98 stated that a 10% reduction in S-8 personnel (3 persons) was likely if a more automated receipt and issuance process were instituted. This largely rests on automated tagging schemes and a well-connected NCTSS backbone.

4.3.1.7 Ship to Shore Interfaces

Most of the material coming to the ship goes through a common staging area. The material is palletized there and then trucked down to the ship when asked. More care at this location to potentially include tagging of material could be beneficial.

4.3.1.8 Operator Input

As described in the personnel area, it was very evident to me that the thought of manning reductions was a frightening thought to these folks. They are undermanned and heavily worked today. They must support shipwide working party demands as well as multiple collateral functions beyond that of the logistics material movement. They would view any change that could permit them to free up junior personnel to permit them to be working along side of more senior personnel as a big enhancement. This would support on the job training, enhance overall divisional capability and enhance the morale of all

involved. It was clear that the physical demands of loading and moving the material are the most cumbersome part of their job today, and it is in this area where a lot of early design effort should be expended. The supply department supervisors would like a more automated material tracking/inventory solution, but they insisted that any such solution would need to be near 100% accurate, and not generate a collateral work load addition to their already overextended workforce. In other words, the application of technology for automation needs to really support a work load reduction.

4.3.1.9 Summary of Observations

Whereas the greatest stress on an aircraft carriers logistics system is in the final days prior to an extended deployment, the observations made aboard Truman as she prepared for local area operations did provide at least a rough order of magnitude snapshot of current configurations, flows and issues. It was clear that even with this substantially reduced volume of stores being loaded on the ship that particular day in February, that it was a cumbersome process not that much different from that I had experienced first hand onboard 688 class submarines. Working parties consisting of dozens of people were unloading pallets for the receipt and storage functions, and a lot of paperwork verifications of material was being done. The weather was reasonably favorable, but it was clear that the entire process would be greatly stressed in adverse conditions where the management of the paper would be even more difficult.

As far as material velocity onto the ship and away from the loading location following receipt was concerned, it was clear to me that there would be sufficient time to apply RFID tags to the material without slowing down the process too much. Ideally it would be most beneficial if the material was tagged prior to delivery to the pier such that the pallets could be receipted for by passing the pallet, or even backing the truck over an RF reader prior to lifting the material onto the ship. Similarly, an RF reader could be applied on the conveyor belt rig that is used to load non-palletized material to capture RFID tagged items being loaded by that system. In addition, if the end user, work center, or specific storeroom storage location is known prior to the pre-delivery palletization

process, it would better support material velocity gains through the application of RFID. The bottom line is that there is most certainly room for improvement in the receipt process.

As described in the detailed observations from this site visit, there is also room for improvement using automated tagging schemes such as RFID in the inventorying process. Inventory validity and the potential gains associated with shifting the burden of accuracy from the man to the machine for the low end production tasks was met with favor by the various supervisors in the supply department provided that inventory validity was not compromised.

Thus, the positive feedback associated with the research posed by this thesis to identify a viable, more automated material tagging scheme, and an integrated, IT based overall Material Handling Information Management System (MHIMS) served as an initial cut validation that this thesis was addressing an important issue.

4.3.2 Submarine Group Two Supply Site Visit

Recognizing that automated material handling may also be useful as a manning reducer, or at least a life cycle cost reducer onboard submarines, a discussion with key personnel in that sector was pursued. Master Chief Hubert, the Submarine Group Two Mess Specialist responsible for monitoring and assessing the food service performance of all of Atlantic Fleet fast attack submarines, stated that the incorporation of material tracking technology that would ease the burden on the mess specialists for inventory and break-out tasks would be helpful. He stated that the way food is managed onboard submarines is quite cumbersome. A system known as the Food Service Management (FSM) is used to maintain breakout usage, generate food order requirements, and track food service personnel management actions. This Lotus Notes based system is standalone and does not interface in any way with any other logistics application on the submarine. Furthermore, it is not consistent with the Microsoft Office application requirements of the

Information Technology 21st Century (IT-21) specification governing computer resources upgrade expenditures.

The general flow of food and support administration onboard a submarine goes as follows:

- The lead mess specialist develops a cycle menu (6-week plan).
- A food service person pulls the associated recipe cards and enters in the ingredient requirements and serving projections.
- A full listing of the food demand is generated by the program and is printed for review and requisition approval.
- This hardcopy requirement list is forwarded through the supply officer for authorization and then sent to the off-hull vendor who in turn fills the order.
- The food is delivered to the ship and loaded into the appropriate storerooms.
- Food is broken out on a daily basis to support making the planned meals.
- The broken out food is debited against the inventory by manual entry into the FSM system.
- A manual inventory of current food onboard is conducted monthly as a means to validate proper usage, and to correct any databank errors which may have occurred when entering in the breakout values over the month.
- The cycle continues.

This process is largely manual, and is prone to numerous human errors. The mess specialists conducting this effort are typically working 14+ hour days, and the record keeping aspect of the job is occurring well into the evening. The current requirements for tracking the goods are very specific. For instance, if chicken is provided in different packaging, or from different vendors, then it will have different codes in the FSM system. This in turn requires that when the manual inventories occur, a tremendous level of detail be maintained. This equates to a full division two-day event every month to meet the requirements. If an automated inventory-tracking scheme could be applied, then it is reasonable to assume that the inventory and breakout updates could happen

automatically, and that these values could be compared to a historical or projected usage curve based upon the cycle menu in use. Any deviations from the projected vs automated actual usage would then be the focus of the food service supervisors. This would permit a much more efficient use of their time in true value added endeavors. A similar conclusion brought up at the 16 July 1998 Navy Automatic Identification Technology (AIT) Requirements Working Group Meeting was that a huge amount of effort is being expended to manually inventory the foodstuff on Afloat units.[31]

In discussing the potential gains of providing tracking tags onto general stores, the Group Two Supply Clerk Chief stated that the SNAP system already does a good job of tracking goods. The point here is that general stores are used at discrete times, typically for repair efforts. When these parts or components are called out of the system there is a strong paper trail and subsequent reordering process in place already. Furthermore, most of these parts are housed in lockers all over the ship rather than in storerooms. Thus, he felt that the application of automatic tracking tags on this general logistics materiel would be of limited value; however, if a cost effective, automated solution were possible, it should be evaluated.

A few areas of general logistics materiel that may benefit from an automated tracking technology would be Operating Space Items (OSI) and consumable items. The OSI material typically gets delivered to a ship during its initial construction period, is not centrally tracked and is expensive to replace. This material tends to get lost when it is displaced for onboard maintenance efforts or is offloaded for overhauls and major availabilities. The consumable items get pulled out of supply/ stowage lockers without any associated paperwork, and as such some automated means of tracking usage or inventorying may be of use.

As a final point in the submarine logistics tracking area, it could be pointed out that during the initial loadout of a submarine there may be some value added in applying

[31] Navy Automatic Identification Technology requirements Working Group Meeting, http://www.ait.std.caci.com/public/inutes/071698min.htm.

tracking tags. It is during this protracted event that a bulk of the long-term stores is added to the ship, and it is the most likely time where human error could occur. Perhaps application of tracking tags prior to loading, and then a subsequent reader pass-by of respective lockers following the total ship loadout could be used to validate items. This is a major event in the life of a ship, and it is one where accuracy is absolutely necessary. If automated tracking technology can improve the accuracy, while at the same time not adversely slowing down the process, then it is something that should be specifically evaluated in future studies.

Section 9.4 provides a rough order of magnitude assessment of the potential gains associated with fielding an RFID solution for logistics material as part of the new construction outfitting process. The specific mix of RFID products that would be necessary to provide a reliable solution that does improve efficiency will require field-testing and is likely to consist of a variety of RFID products. Chapter 7 provides an analysis of applying RFID toward the OSI tracking scenario, but more in-depth analysis would need to be conducted for the other portions of the logistics system. Finally, the bottom line decision point will require a cost-effective solution rather than an application of technology for technology sake.

4.3.3 Supervisor of Shipbuilding Electric Boat Site Visit

Electric Boat is in the process of upgrading its material management tracking system to the Real-time Outfitting Management Information System (ROMIS) for consistency with all Navy supported shipyards. The Supervisor of Shipbuilding, San Diego has been charged by NAVSEA 04 to be the lead developer of the ROMIS system that is fully Y2K compliant. This system is envisioned to provide a requisition material tracking capability across shared databases for both Government Furnished Equipment (GFE) and Contractor Furnished Equipment (CFE). The use of automated tracking technology is desired to reduce manpower needs as well as increase accuracy of data input, and at this point proven barcode technology is being evaluated.

The concept of operations for this system involves the application of shipyard generated barcodes at the receiving warehouse. These barcodes are then scanned into the ROMIS data banks and as the material moves through the shipyard and eventually onto the ship it is tracked. The in process movement of the material can then be used to generate various management reports to measure efficiencies of material movement, job material staging percentages, and potentially tie in the financial aspects of the process. The ultimate goal of the system is to provide a paperless method of managing the material flows from design to production and finally to a seamless handoff to the SNAP system for life-cycle support.

A number of issues or at least decision points that need to be designed into the system must be determined soon. The first item is to identify what information needs to be carried on a tracking device for a particular piece of material, and to evaluate the need for updating that information. Some of the material data that would provide value include:

- Stock number
- Noun name
- Quantity
- Allowance Parts List number
- GFE/CFE designation
- Special handling requirements such as Hazardous Material (HAZMAT)
- Shelf life

As will be described in Chapter 5 of this report, there are memory limitations for 1-D bar coding that may preclude the ability to tie all of the desired information for an item onto the barcode. This may be solvable with 2-D barcodes or more advanced tracking devices such as Radio Frequency Identification Devices (RFID) or Contact Memory, or it may warrant consideration of placing more of the tracking data into the databases and less onto the material itself.

A complicating factor in applying a tracking technology in the production area of the ship's life is that there are many different categories of material which all have special handling and accountability requirements. Each of these materials is called into the construction sequence or outfitting process at different times and involves different organizations and transfer requirements. Thus, in designing the ROMIS system, and in optimally establishing the Material Handling Processes (MHP) for a Naval ship it will be important to capture all of the requirements and where appropriate to recommend changes to the requirements. This highlights the fact that the toughest part of implementing the new tracking technology rests upon the migration of the organizational culture to capture its potential.

Organizational and procedural changes have been occurring and perhaps the most notable example is the transition to an electronic COSAL. As recently as 5 years ago the COSAL maintenance was largely a manual process which required tedious attention to detail, massive paperwork trails, and numerous man-hour expenditure by all involved in the process. Today the process is largely electronic, and has proven to be much more accurate and less manpower intensive.

It is hoped that the ROMIS system, and the focus toward producing a life-cycle cost optimized platform will yield an ever improved transition between new construction and the transition into the operational fleet for both submarines and surface warships in the future. This will require ship designers, producers and life-cycle maintainers to all migrate toward a compatible infrastructure composed of shared databases, fully or at least maximized automation schemes for inventory tracking, and support of operator-defined report generation from the MHIMS.

4.3.4 Northeast Regional Maintenance Coordinator Site Visit

As described previously, the Navy has established a regional organizational structure to try to pare down its infrastructure overhead costs. The Regional Maintenance function is positioned under this umbrella and is specifically charged with reducing the maintenance

expenditures of the operational fleets today. The general method is to pull together the maintenance resources in a given geographic region and to distribute maintenance tasks in an evenly loaded fashion. This is particularly difficult when one considers the fact that different platforms and systems are typically supported by different maintenance organizations all of which have unique maintenance tracking systems. As described previously the NALCOMIS system is used for aircraft equipment maintenance, and the MRMS system is used for general ship maintenance. Even though the actual maintenance efforts and material may be the same for equipment in each of these categories, it has proven to be very difficult to pass work between the two systems and associated organizations. Efforts have been employed to create an interface program known as Joint Compatible Automated Logistics System (JCALS), but it has proven to be a daunting task. A further complication is the fact that the MRMS system is unable to meet Y2K requirements and a shift to a Logistics Data System (LDS) traditionally used by Trident submarines is being pursued today. This affects the Naval Ship Support Facility (NSSF) at New London, and will affect the interface between this organization and the region's shipyards namely Portsmouth Naval Shipyard (PNS) and Electric Boat (EB) shipyard. Portsmouth uses a system known as BAIM, and Electric Boat uses a commercial system known as MRP-2. All of these systems have been designed to accommodate work efforts from work package generation through material requisitioning to final work closeout, but none of these systems can electronically talk with one another.

The point in bringing this aspect of the life-cycle support for Naval warships is to highlight the fact that in all areas there needs to be a migration toward an open, interoperable IT infrastructure. These systems all interface with the logistics support aspects of the platform, and as such must ultimately interface with the NCTSS supported SNAP program. This migration will take vision, perseverance and it must be clearly understood that evolutionary gains toward a common goal over a lengthy period of time is much better than a haphazard jump to an unknown condition. The operational state of the fleet is at stake, and it cannot be jeopardized.

4.4 Summary of Findings

Currently the NCTSS migration plan across all platforms is progressing smoothly to yield an interoperable computer infrastructure. The TAFIM and IT-21 initiatives to leverage computer resource investment toward a PC based networked communication system is also moving along smartly. There is one area, however, where additional effort should be employed in automated material tracking. Currently a smattering of barcodes, RFID tags, Contact Memory Devices and commercial UPC symbols mark Navy logistics material, but there are no specific Defense Logistics Agency (DLA) studies looking into the application of RFID for Navy, general logistics tagging today. There are initiatives for the Marines under the Total Asset Visibility (TAV) program, and most recently for high cost, greater than $1000 logistics material, for Army. A similar investigation should be pursued for Navy logistics

An issue that is likely to emerge as these customer driven solutions reach the fleet is that a myriad of RFID/ barcode/ Contact Memory Device (CMD) tags, each requiring a different reader for data capture will further complicate the lives of our sailors. It is therefore; essential that DLA, the Navy logistics leadership, and NAVSEA as the ship design leader determine what scheme that logistics space layout and IT solutions will be accommodated.

Should RFID technology be part of that mix to meet Admiral Reason's comment, in his *Sailing New Seas* article, which said "hard, objectively measured, incontrovertible data is key". If so, it must be understood that field testing and more detailed Business Case Analysis (BCA), similar to that done by NSWCIH in their application of RFID technology toward lifecycle management of ordnance, be done in time to support ship design efforts underway today.

The gap in analysis of RFID as a potential element in an automated material tagging scheme prompted detailed analysis of tagging technology as part of this thesis.

5 Evaluate Commercial Practices with Emphasis on Tracking Devices

As described in the background research and site visit analysis, it appeared that the greatest weakness in today's shipboard logistics system was material tracking. The next step was to identify what technology or methods the private sector had employed to address this issue as part of its Integrated Supply Chain Management (ISCM) system. The key drivers for an automated ISCM are increased material velocity, and improved material visibility at competitive costs with near 100% reliability. To meet these objectives many businesses established a web presence for customer and vendor interface, and they invested huge sums of money to upgrade their computer network infrastructure. There were general trends toward "open", standard information exchange protocols with layered security schemes to ensure that data was authentic and tamper proof. In the area of material tracking, RFID was emerging as a key technology to meet the visibility and reliability goals of the ISCM system. This section of the thesis will characterize the RFID technology mix, and will provide an overview of how this technology has been employed alongside other material tracking schemes in the private sector.

The initial intention was to conduct an analysis of the ISCM systems employed by some of the more successful logistics based companies such as Wal-Mart, UPS, and FEDEX, but it became readily apparent that these companies had no desire to reveal details about their ISCM systems. This caused a shift of focus toward studying the RFID vendor market to identify and define the various RFID tag types, and to generate of list of success stories associated with the application of the technology. The Internet provided good coverage of the vendor market, while the Automated ID News magazine provided a good overview of industry-wide initiatives. Some general highlights identified in this portion of the research were that most successful businesses today are spending a large percentage of their operating income on IT, and view technology as the enabler to global competitiveness. This is being fueled through the emergence of Electronic Commerce (E-Commerce) "customer-of-one" concepts to enables faster, lower cost, and more efficient commercial transactions among enterprises and individuals. Estimates are that

by 2002 that over $350 billion worth of goods will be bought and sold over the electronic medium, and that over 90% of that value will be in support of business-to-business activity.[32] Thus, it is apparent that technological advances in the exchange and control of information via the Internet, powerful logistics planning software, and in material tracking devices, such as RFID, are driving the process.

Employing electronic networks is promoting a rapid shift to a supplier to manufacturer to the customer interface with forecast, order availability and shipment information. This requires universal, open standards for information exchange and will support financial transactions, supplier relationships, marketing, customer service, internal communications, electronic distribution and retrieval information, and shared knowledge databases which brings us back to Admiral Reason's comment that "hard, objectively measured, incontrovertible data is key".

There is also an emergence of Enterprise Resource Planning (ERP) vendors such as Manugistics and i2 Technologies who have created good supply chain optimizing software products to tie the ISCM system together. Similarly Microsoft is pursuing a Value Chain Initiative (VCI) to develop industry-wide standards for cross application information exchange on the Internet based on Windows NT. This effort is supported by many of the major logistics service providers and software developers such as i2 Technologies/ InterTrans Logistics, Numetrix, Sterling Commerce, and UPS Worldwide Logistics.[33]

5.1 Tracking Technology Overview

Material tracking technology has evolved to the point where some form of it is likely to be used in nearly every application. It is largely affordable, and the potential reliability and efficiency gains simply cannot be overlooked; there is a fast paced trend toward

[32] John G. Reeve, The Electronic Commerce Challenge for Global Shipping, A. T. Kearney, February 1999.

[33] Ibid,.

the use of higher tech tags such as RFID to meet real-time, automated tracking desires of the high-end customer. Specific highlights of the technology available, and current trends in the commercial sector, as well as DoD use, are presented.

5.1.1 Bar Code Technology

Bar codes, which consist of an array of narrow rectangular bars and spaces within a given symbology, permit scanners to capture data and submit it to a central computer system. This approach greatly improved accuracy and efficiency over manual data entry methods. The major drawback of this technology is that it requires a close/ line of sight read, and this in turn requires that the operator properly position the material in front of the reading device. Its strengths are that these devices are inexpensive, disposable, and are common in the DoD and in the commercial sector. Some drawbacks to the technology are that they are static codes with very limited data storage capability, have a very low tolerance to damage, and have a lot of human involvement involved in the read.

There are two principal bar code symbologies, namely linear and 2-Dimensional (2-D). The linear bar code method is employed on most products in the commercial sector via the UPC symbol, and to a large extent by DoD for general logistics material, although it has not reached a universal coverage yet, nor is it ever really expected to do so. 2-D symbology, which can hold substantially more data (1850 characters as compared with 20 characters for 1-D bar codes), is more tolerant to damage (due to check sum parameters in the data field), and permits more rapid scanning with desired accuracy. UPS developed such a symbol to increase the speed of their scanning lines to hundreds of feet per minute. This 2-D bar coding technology is used for ID cards, and is being considered for a number of additional applications by NAVSUP.

5.1.2 Optical Memory Cards

These devices require contact for read, are able to withstand harsh environments, are inexpensive and do have established standards. On the negative side they offer slow data transfer rates, a lot of human involvement in the read, and the reader-writer device is not portable. These devices are best when a data audit trail is required or if a large amount of data must be stored.

5.1.3 Contact Memory Cards (CMD)

This approach involves tagging material with contact memory chips. They can hold material tracking information, and are cheap. This technology does appear to be an ideal choice for weapon systems, heavy machinery, ground support equipment and other equipment that is subjected to extremely harsh environments. One application of CMD is for Aircraft Depot Level Repairable (ADLR) material to carry serial number, part number, manufacturer's number (cage code), requisition number, Job Control Number (JCN), rework date, and time since last data update to permit the material history to reside on the component itself. It is hoped that this will reduce the likelihood of having a loss of configuration control or run hours and the associated maintenance requirements to bring the equipment back on line. One big drawback of this technology is the fact that there is no real time access to the component. Reading of the material requires direct contact with the CMD by a reader, and then this data is downloaded via an RS-232 cable into the NALCOMIS data base.

5.1.4 Radio Frequency Identification Devices (RFID)

There are three different types of RFID products namely, passive (no battery required), active (battery required), or semi-passive (sleeping active) RFID tags. The commercially available passive devices do not provide as much data storage capability as the active tags, but this is just a market demand matter rather than a technological limitation. The range for the passive tags is substantially less than the active tag due to the need for the passive tag to backscatter incident RF energy back to the reader. This creates an r^4 versus an r^2 energy reduction equation.

The real benefits of the passive tag are that they are relatively inexpensive (about $1.00 for the TI TIRIS tag), and do not rely on battery power for operation. The semi-passive tags attempt to capture the positive attributes from the passive tag in reducing the battery demand imposed by a straight active tag, while at the same time providing the greater range capability of the active tag. These tags are awakened when placed in a read field and this in turn establishes a path for the battery to generate a response signal. The battery life for these tags, although greater than the straight active tag is still less than 10 years in a typical environment. This life restriction is caused by latent battery leakage. The specific type of battery used in RFID applications is the lithium thionyl chloride battery.

It appears that 1999 will be the year for numerous pilot projects designed to apply this product line. There is an estimated 40-55 million per year RFID product market today.[34] The vendor base is growing and it almost appears as if the limitations for the application of this technology will only be bounded by one's imagination. Furthermore, vendors are scrambling to get their products to the market first, are readily offering to conduct field testing for specialized applications and stand by to grab their piece of a projected multimillion dollar market.

Martin Swerdlaw in his Circle Reader Inquiry article stated that people want solutions not technology, and until this is done, multi-million dollar investments are unlikely. He estimates that in the time period, 2010-2015, between $10 billion to $15 billion annually will be spent on the product. The only issues are standardization, and meeting the needs of the right customers at the right time.[35]

[34] Michelle Acosta, "Taking the healthy choice with bar code labels", Automatic ID News, January 1999 Vol.15 Number , , , page 49.
[35] Martin Swerdlaw, "The Supply Chain Wants RFID solutions, not technology", Circle reader inquiry.

5.1.5 Tracking Technology Summary

Bar code shipping labels is no longer state of the art, but they are generating savings by permitting manning reductions through automation. Shipping labels enable automated receiving and improve inventory accuracy, produce millions of dollars in savings, and have forced a number of companies to comply with major customers such as Wal-Mart. The first real threats to this technology are coming in by way of such innovations as a Texas Instruments (TI) TIRIS RFID product, and a Motorola ink-based antenna BiStatix product. The cost of these high tech devices are less than a dollar, and their large memory capability (up to 256 Kbytes) and their non-Line-of-Sight (LOS) read capability is offering higher levels of automation and performance. As stated by Kevin Maney in a recent USA today newspaper article, "Until RFID gets super-cheap, bar codes will stick around. But like carbon paper, eight-track tapes and quill pens, bar codes seem destined to be eclipsed by something better."[36]

One thing that is for certain is that the integrated circuit RF tag will never be as cheap as linear barcode, thus the application of the RFID technology will be driven by the real productivity enhancement and benefits for the user that this technology can bring. There are small, inexpensive RFID tags that could fill a number of freight-related or logistics functions. When prices drop much below a dollar, RFID tags should begin to displace barcodes in niche applications.

The choice between CMD and RFID rests upon the environment that the tagged material will be employed in. For instance, in the harsh RF environment on an aircraft carrier flight deck non-RF products such as CMD or 2-D bar-codes may make better sense, but pilot testing should be done to confirm this. One of CMD's biggest drawbacks is that it cannot provide the real-time access that RFID can with a periodic or on demand interrogation of the tag. Further performance differences between CMD and RFID are

[36] Kevin Maney, "High-tech tags mean days of bar codes may be numbered", USA Today, 9 April 1999

likely when condition based monitoring schemes that employ Microelectromechanical (MEMS) temperature and vibration sensing devices are incorporated into the RFID chipsets.

5.2 Examples of RFID Applications for Identification and Monitoring

The first use of the technology in the transportation sector was in the rail industry beginning in the mid-1980s. Today a variety of RFID devices are used in warehousing and manufacturing applications as well as to manage traffic flows, and automated credit card authorizations at the gas pump with devices such as the Mobil Speed Pass.

One application of this technology is in baggage tracking at airports. British Airways and the International Air Transport Association (IATA) estimate that 60 million bags per day are handled at airports and that this technology is worth investigating for efficiency and reliability reasons.[37]

Sainsbury's of the U.K. and El Corte Ingles of Spain are conducting trials of RFID tags embedding in paper labels to control inventory. One US Company began such a test in December of 1998, and if it goes well, it is not out of the question that they will demand vendor compliance.[38]

John Burnell's article mentioned the Philips (I-code), Texas Instruments (Tag-It), and the Gemplus (GemWave) as being less than $1.00 today. It also pointed out 3rd party hardware manufacturers have created read/write units to process tags from multiple vendors.[39]

Information technology for the identification and monitoring of cargo and equipment in a

[37] John Burnell, "Making Information part of the Package", Automatic ID News, January 1999 Vol. 15 Nubmer 1, page 39.
[38] John Burnell, "Industry , Users Romanced by RFID proposal.", Automatic ID News Vol.15 Number 1, January 1999, page 38.
[39] Ibid., page 38.

real-time basis has come onto the scene as well.[40] Active RF with battery powered minicomputers can provide inventory status in transit. DoD effort in this area was intended to permit read/write (R/W) of RF tags to contain the entire manifest. This approach, which has been applied in the NFESC Recording and Tracking Technologies (RTT) initiative has provided the required visibility of sensitive cargo to support more effective field operations for the Marine Force.[41]

The following sections will describe a retail application of RFID and an overview of some recently pursued DoD projects that used integrated applications of RFID technology. The goal of these initiatives is to improve material velocity, improve on data acquisition accuracy, and to permit lifecycle cost reductions.

5.2.1 Lucent Technologies Electronic Price Label (EPL) product

Lucent Technologies in cooperation with NCR has developed an EPL system that features two-way communications between a computer-database-driven radio and low-cost electronic price labels to ensure accuracy and reliability. This product was designed to solve the problem that exists in retail where the prices shown on the store shelves do not agree with those displayed at the checkout counter. The problem is that the price labels are manually applied to the shelves and other display areas in a costly, labor-intensive, error-prone way. This in turn has led to numerous judgments against the retail stores, and created a big demand for automation.

The system developed by Lucent consists of an In-Store Processor (ISP) where a price look-up file resides. This file associates a bar code on an item with a price, and the ISP tells the Point-of-Sale (POS) cash registers what price to associate with a given bar code. The system has ceiling-mounted Communication Base Stations (CBS) that are wired to one another and a master controller. These then transmit updated price information to the

[40] Anne D., Aylward, "Intelligent Transportation Systems and Intermodal Freight Transportation, Final Report", Dec 1996, page 17.
[41] Anne D., Aylward, "Intelligent Transportation Systems and Intermodal Freight Transportation, Final Report", Dec 1996, page 18

EPL's who acknowledge receipt back to the CBS. The design philosophy of the system was to keep the CBS hardware dedicated to radio communications, and to retain most control intelligence in the master controller. This allows all software to be in the master controller and permits use of higher language protocols. Since the EPLs must have power to transmit, and since it would be very inconvenient to continually replace batteries or provide a continuous power source, the design minimized power requirements to support the use of a small battery. [42]

The point in describing this system is to show that a variety of RFID products tied into an integrated solution can provide big gains in systems where access to real time, coordinated logistics management is required.

5.2.2 DoD's Total Asset Visibility (TAV) Initiative

Until recently, the application of RFID tags in DoD has received limited support. The rapid technological advance of this technology, the tremendous price reductions of a wide range of products from an ever increasing field of vendors, and the success stories from those first few DoD programs which have employed the RFID products are causing a shift of opinion. The Naval Sea Systems Command, as a customer, and the Defense Logistics Agency as the Navy's AIT coordinator are beginning to include RFID in their business case analyses.

This technique has been applied in the Recording and Tracking Technologies (RTT) program in support of TAV by the Naval Facilities Engineering Service Center (NFESC)-Port Hueneme. In this application a combination of material tags, and container seal tags were used to create an electronic manifest which could then be interrogated from a remote transceiver. The goal of the project was to permit a real-time access to logistics

[42] James G. Evans, A Low-Cost Radio for an Electronic Price Label System, Bell Labs Technical Journal, Autumn 1996, page 204

material as it passed nodal, read points in the process. In addition, this application of the technology employed Global Positioning Sensing (GPS) transceivers on key components of the logistics flow to actually track the material moved between nodes.

5.2.3 Ordnance Storage Project (OSP)

In a similar fashion active RFID tags are being employed in the OSP being pursued by NSWCIH to provide real time asset visibility of ordnance and to provide on product configuration management and Microelectromechanical (MEMS) temperature sensing for energetic and fuel refurbishment cycles. The Business Case Analysis (BCA) for this application touts a Return on Investment (ROI) of 26:1 over a 4 year period.[43] The costs included to make this analysis were:[44]

<u>Current Costs</u>

- Inventory: To include all costs to perform execution, reporting, inspection, safety, Ammunition Management and Accountability Review (AMAR), Level of Effort (LOE) and Segregation (SEG).
- Causative Research: To include all costs to reconcile the report with the list and bin.
- Transportation: To include all costs to perform second destination transportation, including distribution, redistribution, surveillance, maintenance, and demilitarization.
- Manpower: To include the cost of personnel to perform demilitarization, surveillance, and maintenance.
- Readiness: To include the cost associated with maintaining an accurate database for ordnance inventory.

[43] Commander Naval Surface Warfare Center Indian Head Division, A Technical Proposal to Modernize Ordnance Management Utilizing RFID and MEMS Technologies, 2 October 1998, pg. 27.
[44] Ibid., pg. 41-43.

RFID/MEMS Implementation Costs

- RFID/MEMS : To include program office cost to design, modify, test, and demonstrate an inventory/surveillance system.
- Procurement: To include the cost to award and execute a contract for the manufacture of all components and fielding of the system Navy-wide.

Determine the impacted functions and expected savings

- Elimination of efforts that would no longer be required.
- Reduction in effort for non-value-added activities.

Finally to perform a financial analysis

- Payback calculation
- Internal Rate of Return (IRR)
- Return on Investment (ROI)
- Net Present Value (NPV)

As previously stated the internal analysis conducted by NSWCIH indicated a substantial ROI, and this was further verified in an independent analysis by Peat Marwick LLP.

5.2.4 Reduced Ships-crew by Virtual Presence (RSVP)

Another application of this technology is that being employed by the ONR sponsored RSVP program. RSVP is an initiative to insert automation technology toward condition based monitoring of equipment, automated damage control for reduce manned ships, and to create a sensor infrastructure which can potentially tie in with other shipboard equipment to permit the ship to more effectively respond to changing operational conditions. Several Navy and private laboratories are involved in the research, and it is hoped that fieldable solutions to support reduced manning warships will be generated.

One concept being employed for this program is to develop an energy scavenging device which will have a transmit performance similar to an active RFID tag, but will not require a reader. In addition, there will be extensive use of the MEMS technology to permit real-time monitoring of key physical characteristics of the environment or system to provide anticipatory input into automated control systems.[45]

Based on a projected demand of more than $700 million/year by the year 2000, and the rapid reduction in unit price for RFID tags, Lucent believes that market is ripe for entry. They contend that low-cost hand-held scanners and handy terminals used for inventory control could be networked using modulated backscatter (passive) radio technology. Wireless communication in support of inventory tracking is very likely. [46]

5.3 Potential uses for RFID Technology:

RFID can be employed for logistics material tracking, configuration management of installed or stowed equipment, and for condition based monitoring. A number of applications of this technology have already been tried in the commercial sector to include[47]:

- Electronic Article Surveillance (EAS) alerts upon unauthorized movement,
- Shipping container and railcar tracking, which tag rail cars and containers,
- Animal tracking where small RFID devices are placed under the skin of the pet for tracking purposes,
- Vehicle access and control into secure areas,
- Personnel access,
- Environmental monitoring of transport material,
- Aircraft baggage tagging,

[45] Science and Technology Working Group, Reduced Ships-crew by Virtual Presence (RSVP) FY 99 ATD, July 9, 1998, page 6.
[46] Ibid., page 213.
[47] Joe Burnam, "Freight Transportation Industry Standards", SAVI Technology, May 7, 1996.

- Postal stamp replacements,
- Configuration management applications,
- Condition based monitoring of weapons and mechanical equipment, and many others.

5.4 Potential Risks/ Issues with RFID Technology

RFID is an emerging technology that does have some risk. In particular, there are currently no International Standards Organization (ISO) standards to mandate product protocols, and as such there is a possibility that one vendors product line will only be readable by specific read devices. In addition, battery capacity currently limits the active RFID product life to 7-10 years. Finally, capturing the logistics and maintenance data and then distributing it over the various information networks will need to be provided with the proper security scheme. Each of these issues as well as relative risks will be presented below.

5.4.1 Lack of Standards

The lack of an approved standard for RFID products is clearly the biggest issue and this does create risk toward investing money into readers and tags. Industry analysts generally feel that it is far more likely that the 3rd party hardware vendors will simply develop readers that can query various frequencies and characteristics across the spectrum of RFID vendors rather than waiting for the approval of a standard. The reason for this suspicion is that there are many elements that must be considered when selecting a standard and it will simply take time to work through the issues. Key characteristics that will require specification include[48]:

- Worldwide acceptance
- Bandwidth

[48] JECPO Homepage, 5 Feb 1999, page 6.

- Wave bending/bouncing
- Frequency
- Noise
- Protocol
- Radiated Power
- Range
- Applications
- Modulation technique
- Encoding technique
- Battery
- Cost
- Other Standards

Patricia O'Shea, senior industry analyst for market research and consulting firm, Frost & Sullivan, further stated "The fact that the top two companies, Texas Instruments and Phillips Semiconductors in the sector are working together will have a positive impact."[49] These companies have already submitted such a request in November of 1998, but it is not expected to be approved for at least 18 months. This highlights a full recognition of the risk associated with not having standards that are properly characterized, and the subsequent resistance toward the application of this technology both in the private sector and the military sector until a clearer path toward universal solutions is evident. This resistance is driven by the concern that without a standard that the initial capital investment to employ an RFID product would be at risk. Texas Instruments and Philips understand this, and have gone on record to state that they are soliciting reader vendors to

[49] Bert Moore, "Radio Frequency Identification: Where's the Revolution?" Automatic ID News, January 1998, page 43.

make readers that can read both of their products. This represents a large percentage of the passive RFID market, and is a big step toward establishing de facto standards and will do a lot to accelerate the rapid insertion of this technology.

To gain a better perspective on this issue, Bert Moore of Automated ID News suggests that the lessons learned with Bar Code technology insertion should be reviewed to get a sense of what to expect in the area of RFID. The model goes like this[50]:

Step 1: Development of the technology
Step 2: Proliferation of options (symbologies, readers, and printers)
Step 3: Creation of standards and technical specifications (symbologies)
Step 4: Creation of user-driven standards (such as U.P.C.,AIAG, and LOGMARS) based on "approved" technical specifications.
Step 5: Consolidation of the technology around user standards.
Step 6: Improvement and expansion of the technology
Step 7: Increased user acceptance, development of new applications.
Step 8: Repeat from step 2 as required.

This follows the VHS vs Beta tape evolution as well as the IBM vs Apple computer scenario that has played out over the past couple of decades. We can expect the push for a solution for a defacto RFID standard to be even stronger under the pressure of a rapidly expanding electronic commerce market.

5.4.2 Battery Limitations for Active RFID tags

In addition to a lack of standards there is a heavy reliance on battery technology for the active tags. Current technology only supports a maximum of a 10-yr life for lithium thionyl batteries placed in semi-active tags. This life is further reduced in adverse

[50] Ibid., page 36.

environmental conditions such as extreme heat or cold. The real issue is the self-discharge rate of current batteries. It is the opinion of Ken Lipton a design engineer at NSWCIH and myself that in the not so distant future the cost of active and semi-active RFID tags will be completely driven by the battery cost. This is one area where additional research, or perhaps new energy scavenging methods should be developed.

5.4.3 Information Security Considerations

Security is a big issue in information systems, especially one that will be managing the logistics flow onboard U.S. warships. It is necessary for decision makers to have complete confidence that the information brought before them and used by their staffs is accurate and has not been manipulated by an adversary to present a false impression.

This concept is known as "information assurance". This requires that computer systems use software that encrypts the information sent over public networks so that unauthorized individuals cannot read or manipulate it, and means that DoD must have a way to confirm the identity of individuals on the network who are sending and reading encrypted information.[51]

5.4.3.1 General security requirements[52]:

- Consistency to handle legacy and new systems concurrently during phase in.
- Scalability to handle the worst case system demand.
- Availability to ensure that security covers the entire system.
- Usability to be operator friendly.
- Business Requirements must be appropriate for the organization.
- Regulatory Requirements for export or encryption need to be adhered to.
- Enforceability as a standard policy.

[51] JECPO Homepage, 5 Feb 1999, page 9.
[52] Bart B. Kelleher, "Open Systems: Feasibility and Uses" Master of Science in Ocean Systems Management Thesis", February 1999, Chapter 5.

- Portability to provide security across different hardware systems.
- Evaluation Criteria must ensure that it measures relevant factors
- Performance above established thresholds
- Flexibility to support seamless upgrades.
- Adherence to Standards to ensure that no security voids are created.
- Interoperability to go across system boundaries.

5.4.3.2 Key Security System Features:

- Identification and Authentication to ensure that only the right people gain access to information by use of passwords and firewalls.
- Authorization and Access Control to define user restrictions.
- Security Auditing to detect penetrations.

The bottom line is that security needs to be designed into the system up front, and it needs to fit into the hierarchy of the existing computer backbone on the ship. Therefore, E-Commerce links for warehouse management, enterprise resource planning or supply chain execution which rely on electronic messaging will need to have proper security measures in place to safely conduct business.

5.4.3.3 Other Potential Issues

In the case of container transport, another potential Achilles heel exists if only the transport container is tagged. The scenario is that if the components within the container are not tagged, and if one of them falls off a shipment (or is removed), then the data base will incorrectly associate a successful material handoff when the transport device tag passes a nodal point when in reality the material is lost. This issue must be considered in the design phase of such a system, and will require diligence by all handlers in the logistics chain.

5.5 Material Tracking Device Summary

As can be seen from this discussion, the selection of the proper material tracking device is an essential element of an automated MHS. This involves a careful analysis of the environment, it requires a thorough understanding of the currently employed logistics system to obtain data in support of accurate BCA's, and it requires an understanding of technical issues associated with employing each of the tracking technologies. A one shoe fits all solution is simply not practical. RFID is the most recent addition to the mix, and as such use of this technology requires a careful analysis. The product line has matured to the point where a careful review of its applicability shipboard should be made. There are certainly technical issues, and of course there needs to be careful cost benefit analysis conducted to warrant selection of these devices over other tracking technologies. Chapter 6 will address some of the technical issues associated with putting RF devices onboard ship, and Chapter 7 will lay out a notional material tracking solution which includes the employment of RFID.

6 Technical Requirement Analysis

All of the material tracking technologies mentioned in Chapter 5 have been employed shipboard except RFID. Thus, the focus of the analysis in this Chapter will be to determine the feasibility of employing RF devices for material tracking onboard ships. RF policy restrictions, data acquisition application program and hardware support devices interface requirement, and the identification of pertinent specifications, and restrictions will all be covered. Finally, since the ultimate goal of employing an automated tracking system is to permit an Electronic Commerce (E-Commerce) paperless logistics flow, which ultimately would be transmitted over commercial phone lines, it is necessary to identify specification requirements or policy restrictions in this area as well. The assumption taken in this study is to assume that policies would remain as is, and any proposed system solution would need to conform within these bounds. On the other hand, if during the course of the research certain policy mandates appeared to be outdated, or seemed to create undue impedance to the application of an MHIMS system, a policy change recommendation would be stated.

6.1 Requirements for Shipboard Employment of RF systems

Electromagnetic interference onboard warships is an important matter. There are specific power limits for such devices depending upon which frequency band the device operates in. MIL-STD –464 defines below-deck field strength limits as follows:

- For metal-hull surface ships, it is 10 V/m (10kHz-18GHz);
- For submarines, it is 5 V/m (10kHz-1GHz);
- This permits unlimited power use for the 2.45 GHz UHF band passive and active RFID tags.

Commercial standards further define the limits as follows:

- In the high frequency band above 1 GHz there is a limit of 4KW or 36 dB,
- In the MF and LF bands there is no power limit.

The IEEE C95.1-1991- IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 KHz to 300 GHz states that a safety factor of 10 should be applied to power allowed. Power rather than field or power density is used to overcome any biases that could come from system gain deviations.

The RSVP project funded by the DD-21 program office, and being technically defined by Draper Laboratories is considering the use of 2.54GHz devices to monitor spaces and equipment. This higher frequency provides high data transfer rates, longer range, and for submarine applications is not limited by MIL-STD-464. As part of the development effort, Kevin Toomey of Draper lab has been involved with a number of at sea tests to evaluate system reliability, survivability, interference, fire degradation and to evaluate the impact of the RF devices onto baseline DD-51 platforms. All tests to date indicate no system or platform generated problems.

The current commercially available RFID tags fall into the following categories:

- Passive, low frequency (125kHz) magnetic coupling (except BiStatix), range limited to about the size of the reader coil. No battery.
- Passive, HF (13.56 MHz), range limited to a few feet.
- Active, UHF (315, 434, or 915 MHz bands), ranges of hundreds of feet.
- Passive UHF (915 or 2450 MHz or higher UHF bands). With no battery, ranges of a few feet at low reader powers. With a battery, ranges of tens of feet.

Thus, the notional automated MHS system described for aircraft carriers and submarines will consider these characteristics and power limitations in its design. RSVP testing to date, and similar testing conducted by NSWCIH and NFESC in their application of RFID has produced no specific technical problems and none are anticipated.

6.2 Interface Requirements with Shipboard Computer Infrastructure

The repair part and general material logistics systems aboard ships use a Microsoft compatible format under the NCTSS application programs. The Food Service Management (FSM) software is standalone, and uses a LOTUS application program. The primary concern associated with employing an automated material tracking scheme given the diversity of these two logistics software systems is to highlight the importance of matching protocols. The point is that the interface boundaries need to be properly addressed in the design of the system.

6.2.1 Food Material

In the area of food materiel tracking, which is managed by a standalone FSM application, the only interface would need to be from the automated tracking readers to the standalone FSM computer for automated inventory and breakout tracking. As a final note for food, there does not seem to be any compelling reason to create an interface between this Lotus Note based application and the Microsoft based SNAP system to support the food service personnel. However, if battlegroup wide real-time tracking is desired, then this system must integrate with the ship's computer backbone.

6.2.2 General Logistics Material

In the area of general material tracking of material stowed in the CVX storerooms, the automated readers would need to feed the data into the SNAP inventory databases. This would require standard PC-based protocols.

In cases where the material is stowed in lockers, the use of portable scanning devices for inventory purposes, or space entrance readers for loading would be required. This in turn may require additional tag data requirements be applied at the ship receipt location.

6.2.3 Common Logistics Interface Requirements

In both of the above cases, it would be desirable for Advanced Shipping Notice (ASN) information to be transmitted electronically to the ship well in advance of the arrival of material. This would permit a large portion of the database updating, and the development of stowage plans without adversely impacting any other ship activity. The point is that when the material is loaded onto the platform it should ideally not detract from any other activity such as flight operations or weapon loading events.

Information is to be transmitted to the platform, and read into the appropriate tracking tag databases prior to the goods arriving on the pier. The efficient movement of materiel from the pier and onto the ship demands that a minimal amount of handling be done on the pier. Therefore, all that should be required at that final step in the process would be to specifically download the data from the database to the tag and then to affix the tag to the goods. This ASN data transfer should be electronic via modem.

6.3 Policy Restrictions for Shipboard Internet Connections

The shorebased side of the IT-21 initiative has T-1 level phone connections planned for all berthed warships. It is through this interface that the ship will conduct Internet transactions to include email and requisitions. When the ship is at sea, this feature will need to be supported by radio communication gear such as Super High Frequency (SHF) data links, or traditional UHF satellite mechanisms. In addition, there will need to be a segregation of classified and unclassified networks on the ship until an effective multi-level security system is created.

6.4 Physical Layout Interface Issues

The tracking readers at food and general logistics material storeroom doors should have no difficulty capturing the RFID data, but the storeroom layout will need to be carefully considered if an automated storeroom inventory scheme is desired. If barcode tagging is

used, then the layout must consider the placement of goods such that it is easy to scan the barcode. If RFID technology is used, then it is necessary to not stack material too deeply or the RFID scanner will be unable to capture the data.

Furthermore, one of the most time consuming aspects of storeroom breakouts is simply knowing where particular items are stowed in the storeroom. It is possible that some combination of tracking technology and storeroom layout design could alleviate this issue.

In the case of locker stowage onboard submarines, the application of RFID brings to light a number of technical issues. First, and foremost since the lockers are made out of metal, and since the RFID antennas are detuned if they are placed within ¼" of metal that a unique packaging will need to be considered. Other alternatives would be to potentially use an emerging ink-based RFID solution being developed by Motorola that would not detune near metal, but a primary drawback of this technology is very limited range with a reasonably sized tag. Another issue with applying RFID to submarine lockers is the fact that since there are so many of them, and because the size, shape and accessibility varies so greatly across the ship, an innovative, hybrid mix of both passive and active RFID tags is likely. Furthermore, a series of pilot tests to truly identify the real issues and to work through potentially optimal solutions is a must. These challenges should not be viewed as show stoppers, but rather should be viewed as required engineering work to properly evaluate this type of application.

6.5 Military Specific Operational Requirements

The military posture for logistics is evolving to be very similar to the Just-In-Time (JIT) inventorying demands of the private sector. As far as the cost, or essentiality of materiel for military applications vs. commercial uses, the difference is fading as well. Thus, the concept of employing Commercial-Off-the-Shelf (COTS) hardware and methods is acceptable and the cost-prudent choice.

The operational effectiveness demands reliable, flexible and very robust logistics throughput. Visibility of logistics flows and real time reallocations based upon mission priorities are routine. This further highlights the importance of an integrated, fully interoperable logistics asset management system for a battlegroup. This must be likewise supported by the shoreside infrastructure under a focused vendor base to optimally employ logistics resources to sustain force-wide battle readiness.

7 Recommend a Notional MHIMS Scheme

The goal of the research was to define a notional automated MHS solution that could support reduced lifecycle cost and manning needs onboard aircraft carriers and submarines. The area where the greatest potential improvements can be expected is in the data acquisition point in the logistics system to enhance receipt procedures and inventorying. Today, these tasks require a great deal of manual labor, are complicated, prone to validity errors, and require a lot of material handling to breakdown pallets and boxes and is where the application of an automated tracking scheme may be beneficial.

RFID has emerged as a potential solution, but there are concerns with a lack of standards for products and reader protocols and with battery life for active and semi-active RFID tags. In addition, a number of the potential applications that should be considered for warship application, especially in the submarine scenario, have not been tried out in the commercial sector. This highlights the fact that employing this technology today does involve accepting some risk. On the other hand, there are clear indications that the technology and its application across industry will continue to accelerate. Therefore, there are also substantial pitfalls associated with not at least investigating its applicability for warships early in the design phase. By conducting this up-front analysis toward the potential application of RFID technology shipboard, it can lead to system solutions which will permit more rapid and cost effective insertion of the technology when the timing and cost is right. There is a definite tie between the physical layout of storerooms, and the specific mix of RFID/ Bar-code/ CMD products used for data capture and at a minimum this does need to be factored into the logistics space, and computer infrastructure design. This chapter will include a BCA for applying RFID to OSI material to serve as an example of the potential gains that this technology can provide.

7.1 Potential Uses of RFID for Ships

This research identified a number of potential applications in the logistics area onboard warships where this technology may help reduce lifecycle costs and manning needs to include general logistics, configuration management, and then a summary list of a myriad of other potential applications.

7.1.1 Logistics area

- Tagging of Operating Space Items (OSI). This would improve upon the manual and inefficient receipt process used today, and is likely to permit better inventory control across the lifecycle and minimize the loss of this unique material in major availablities and overhauls.
- Tagging of Storeroom Items (SRI). This would include the tagging of expensive Depot Level Reparable (DLR) material as well as general logistics and food stuffs. The gains for the DLR material will be a more accurate tracking of the material in its refurbishment cycle resulting in less loss of material, and for the general logistics material it will permit a more automated and efficient receipt and inventory process.

7.1.2 Configuration Management/Maintenance area

- Tagging of installed and spare components. This would permit the data history of a component to be carried directly on that component. This would then provide a means for shipboard maintainers or outside organization ship checks to be conducted in a scan and read mode rather than by use of manual methods. This could potentially save tremendous amounts of time, greatly reduce paperwork, and improve accuracy that could reduce rework and additional time wastage.

This particular application was identified as a possible solution to the configuration management concerns associated with building and then handing off hull sections between Electric Boat Shipyard, and Newport News Shipbuilding. The idea was to tag

the components within the hull form with passive RFID tags to hold configuration data and then to apply an active manifest tag at the hull section access point to query the contents on demand. Just prior to shipment the manifest tag, or reading device, could query the hull section and catalog the contents. This data could then be readily accessed and verified at the receiving end and alleviate redundant, labor intensive shipchecks. Of course accuracy during the placement and data writing phase of the RFID tag application process will require the same level of detail and attention as was required with other tagging or documentation means. The difference between having RFID in this scenario is that it would make it much more efficient to verify the configuration and history of the product for future work or operational control transfer. This is clearly one application that could have broad reaching benefits to the Navy at large, and is one that should be looked into.

7.1.3 Other Potential Applications of RFID

As the cost of this technology drops, and as the computer infrastructure and the need for real-time monitoring of assets increases due to manning reductions, the possibilities of employing this technology are really only limited to one's imagination. The following is a list of potential applications shipboard, but it must be pointed out that it is far from complete:

- Tagging of laundry to support better distribution and minimize wasted effort for sorting and associated morale degradation due to clothing loss.
- Tagging of tools or special test gear such that an alarm will sound if it is taken off of the ship by unauthorized personnel, and to permit a more automated inventory process.
- As an extension of the configuration management process, it is conceivable that one could apply this technology toward the tagout process to support a more efficient tag audit process, and perhaps even a real time feedback into the onboard drawing files for as tagged conditions.

- Tagging of safety gear for topside personnel such that if they should fall overboard, their location and potentially even vital statistics are passed to the parent ship. This would be an extension of what has been presented thus far in this thesis and does rely on the MEMS technology that was briefly discussed in the RSVP program overview.
- The list could really be endless, and the point must be that the end goal of applying the technology must be to reduce workload and/or improve operational effectiveness.
- Security system using a combination of RFID and an Electronic Alert System (EAS).

7.2 Risks associated with using this technology for these applications

- Battery life limits for active RFID tags. Currently limited to a maximum of 10 years, this will limit active and semi-active RFID tag applicability to certain applications based upon maintenance cycles. This will subsequently drive a mid-term tag or battery replacement for those applications requiring the extended range provided by active tags. In addition, it should highlight the fact that alternative power solutions should be considered as is being considered in the RSVP program.
- Lack of standardization. The commercial sector will drive this issue, but the concern is the sailor may be confronted with multiple tags at different frequencies transmitting signals with different protocols that can not be read from a single reader. In effect it would add tremendous complexity to the material receipt, inventory and issuance process. Thus, it will be important to follow the lead of the commercial sector, support the effort already underway to establish ISO standards for interoperable RFID characteristics and to ensure that any applications considered for Navy shipboard use fall within these bounds. It must also be pointed out that RFID tagging may well be applied to material that will make its way to the ship based upon BCA's conducted from supporting activities. This may be driven from NAVSUP or the ordnance managers at NSWCIH. The point is that across the Navy there is a drive to employ improved business practices, and their solutions must be factored into the ships receipt posture up-front.

7.2.1 Technology Selection

A tremendous amount of effort went into researching the RFID vendor market to identify their various product lines, and to gain an appreciation for who and for what application these products were being used. Section 9.5 provides a summary list of a number of these vendors and the performance characteristics of their product lines. Of those companies provided on that list a few stood out and deserve specific mention.

7.2.1.1 Texas Instruments (TI) TIRIS Tag-it product

The TI TIRIS product line is one of the best set of passive products in the industry today. These passive RFID tags operate at a frequency of 13.56 kHz, have a delivery cost of about $1.00, large data capacity, and are being employed in large numbers in various industries across the world. This tracking device has a range of up to 2.5 feet which provides a 5 foot wide coverage when the antenna is looped around the read area. This should provide a reliable data capture window for material moving into and out of a shipboard storage rooms or on the pallet load and conveyor belt systems as material is loaded onto the aircraft carrier. This product line currently supports up to 256 bits of information that should be more than adequate to define the necessary parameters for tracking and the cost is low (about $1.00/tag). Durability and multiple reuse of the product is certainly possible.

TIRIS technology has been used on smart pallets, container-moving gear, airline baggage, and automobile gas passes (Mobil Speed Pass), auto assembly lines, warehousing, security and a myriad of general applications with high reliability and uniformly superb results. The Tag-It product is an effort to produce these tags in a paper-thin configuration that can be embedded in a bar-code type of tag for cheap, reliable and quick application on parcels.

The Tag-it system is capable of non Line of Sight of Sight (LOS) reading in a multiple read scenario. This as well as the reduced cost of using the 13.56 KHz band over the HF

2.54 Hz band being employed by a number of competing vendors highlights the potential gain of using this product.

The principal driver for the employment of the TI Tag-it product in the commercial sector has been the push for an integrated logistics system with real-time asset visibility. Growing capability with declining prices for processing power, data storage, and telecommunications has generated a vertical demand for these products. Supply chain integration is also applying pressure to capture the business processes in the information system. The application of IT has been shown to meet the inventory status demands of the customer, and has generated efficiency gains throughout many industries.

The application of this product requires a clear understanding of regulatory limits for RF application across the globe, and it requires a clear definition of one's logistics system. Specific considerations for employing the Tag-it product, as well as the technology itself, follow:

- Key nodes in the process must be defined, and interfaces at the node must be well established.
- Status of the transported goods with respect to damage or special handling requirements must be flagged.
- Activity levels, congestion problems, or platform degradations affecting the logistics handoff need to be communicated.

The point here is that once the material required is logged into the system, the system status must be accurately depicted. As unit condition, or priority shifts occur across the logistics chain, simulation runs to determine optimal adjustments should be made. Finally, the bottom line is that the RFID tag needs to generate real value in the process to be worth the expense.

7.2.1.2 Intermec Technologies Corporation, a Division of Amtech Systems

This company is providing an Inventory Auditing and Tracking product to Kennedy Space Center, and the Multi-Technology Automated Reader Card (MARC) for automated military personnel identification schemes. They have a wide range of RFID products available and have achieved success in a number of application areas.

7.2.1.3 Raytheon's SAVI product

Raytheon, who recently purchased SAVI from Texas Instruments, also provides a wide array of RFID products. SAVI provided the Recording and Tracking Technologies (RTT) program in support of the Total Asset Visibility (TAV) initiative for the United States Marine Corps being pursued by the Naval Facilities Engineering Service Center (NFESC), Port Hueneme under a sole source contract. They have subsequently provided solutions for a US Army Medical Department Asset Tracking Program (AMEDD) MEDTRAK system to provide real-time visibility of critical medical equipment. They have also provided an automated gate, dock management system for Toyota Motor Manufacturing at Georgetown, Kentucky, and have supported recent applications of RFID for a U.S. Postal Service real-time mail container tracking initiative. These all represent large contracts and total system solutions.

7.2.1.4 Trolley Scan(Pty) Ltd

They are marketing a Trolleyponder technology which has a frequency agile interrogation capability since its antennas are not specifically tuned, and for their product line which operates in the 200 MHz to 1600 MHz range it is anticipated that there will be good performance at very reasonable prices. This feature may alleviate some of the difficulties associated with finding an acceptable RF band to be applied worldwide. The problem with meeting this requirement is that many nations have uniquely restrictive RF regulations and to date there has not been much success in trying to standardize the allowable frequency bands. This particular company touts a myriad of potential applications for their product line, but as of yet they do not have any large contract successes to rave about.

7.2.1.5 General Comments covering the rest of the RFID vendor market

The market is broken into a couple of key categories. There are tag vendors as listed above and in Section 9.5, reader manufacturers, system integrators such as Symbol Technologies, and then international organizations and grouping of businesses who are active in this technology sector. All of these companies are pushing for standards, trying to innovate new applications for the product, and are pushing for lower cost solutions. The customer push from electronic commerce is likely to drive the evolution of this technology at an ever-increasing rate. Thus, it will be important for the new ship design technologists to stay plugged into these market trends.

Should any pilot testing occur it is important to invite a number of vendors to get a broader perspective on the possibilities. For instance, NSWCIH invited 10 vendors to participate in their ordnance pilot test to ensure that they had the proper opportunity to evaluate the best solution for their application. When they ran this test one of the goals was to characterize the relative performance between active and passive tags. As stated above the passive tags are cheaper, but they really did need a high reliability upon query and were going to place tough geometries between the reader and the tags. The testing did yield their selection of an active tag, and a listing of the specific vendors invited to the testing follows:

Honeywell (active tag)
Lanex prototype (active tag)
Randtec Versatag (active tag)
Sarnoff (active and passive tags)
Savi (active tag)
Amtech (passive)
Lucent (passive)
Micron (passive)
Randtec Confident (passive)

7.3 Hypothetical Scenario for applying RFID toward Operating Space Item (OSI) receipt and inventory tracking

This small subset of material is representative of the state-of-the-art and therefore was selected for an in-depth analysis of applying RFID. The methods presented here can be applied to the SRI and configuration management portions of the aircraft carrier and submarine logistics systems, but it will be necessary to collect a great deal of lifecycle costing information to generate a useful BCA. In addition, the application of RFID for these portions of the ship's logistics system will need to more thoroughly consider the interface to the Navy-wide systems of DLA, NAVSUP and repair organizations. It is important that the insertion of RFID at a platform level not adversely impact that platform's ability to operate within the larger shore-to-ship infrastructure.

7.3.1 OSI System Definition

The OSI system consists of 35,000 special stowed items for an aircraft carrier and 3,715 for a submarine. These items include the following types of material:

Damage Control	SPETERL
Ordnance	AIMD*
Safety	ALRE*
Air Wing*	IMRL*
MAMs	AVCAL*
2M	DLR's

**Aircraft carrier only*

Within this list, MAMS and SPETERL are tracked via semi-annual inventories, and rough manpower estimates to conduct these inventories given today's material tagging scheme were provided from SUPSHIP Groton.

This material is currently provided to the ship's supply department for the aircraft carrier initial loadout, and to the individual work centers for the submarine loadout with bar-code labels identifying National Stock Number (NSN), Document number, quantity, work center, Associated Equipment List (AEL), and unit identification number applied. In the case of the submarine, there are specific work transfer papers which are signed by the delivering shipyard trade person and the ships force divisional representative. Once the paper is signed, it is fed into the management-tracking department and annotated as complete on the construction schedule flow sheet. In the case of the aircraft carrier, all material is handed off from SUPSHIP to the supply department from which the divisional turnover occurs at a later time.

The material is stowed in its designated stowage location and not broken out until specific maintenance or training demands require its use. The only exception is when maintenance or preservation efforts in the stowage location force its temporary relocation. This temporary relocation may be brief, or as in the case of an overhaul the material it may be displaced for months or years. It is during these periods of time that the greatest loss of equipment occurs, and where a very accurate tracking scheme is necessary.

7.3.2 Tagging and Inventory Methods

Currently this material is mostly bar-code tagged, and stowed throughout the ship. Many of the stowage locations are in harsh environments that can degrade the paper bar-code labels. Some of the material is bolted into special stowage locations that require disassembly to identify the specific component. Since RFID is less prone to degradation in these adverse environments, and since the reading of these tags does not require a line-of-sight path, it is likely that inventorying can be conducted much more efficiently and that inventory validity will be higher. This equates to less man-hours and less material replacement costs. In addition, RFID provides a hands-off system that will make data entry errors far less likely than that experienced today as the sailor orients the material to obtain LOS reads of barcodes.

7.3.3 Proposed Technical Solution

Pending a BCA verification, it appears that the application of passive RFID tags that can be read with portable readers inserted during the new construction initial receipt process, and further extended to support periodic inventorying across the ship's lifecycle will reduce cost. This is a rather simple solution that will require very little capital investment. It is recommended that pilot testing be conducted to work through the implementation scheme to determine what precautions must be taken to ensure that the RFID tags can be placed without any adverse side effects. Two potential issues come to mind. Specifically, since most of these items will be stowed in metal lockers, it will be necessary to ensure that the RFID tag packaging provides the required ¼" barrier to preclude antenna de-tuning. In addition, it will be necessary to identify the impact of special stowage brackets as they pertain to the placement of the tags. This may in turn need to be an item that is eventually fed into the ship's drawings. The point here is that a total systems approach across the entire ship's lifecycle is warranted. The technical solution for avoiding antenna de-tuning may require a non-metallic isolation barrier inside of the locker, or it may warrant a ¼" packaging buffer around the tag, and the technical solution for choosing the location for tag placement may warrant installation of the tag once it is ship-fitted. These are process issues that can be addressed in the RFID tag specifications and in the construction methods. A rough order of magnitude BCA to characterize the potential cost savings of this application is provided in the following section.

7.4 Business Case Analysis (BCA)

This BCA analysis follows a similar approach to that conducted by NSWCIH as they pursued their ordnance tagging initiative.

7.4.1 Objective

The purpose of this study is to quantify the potential cost savings associated with implementing RFID technology to automate the receipt and lifecycle inventory processes for aircraft carrier and submarine Operating Space Items (OSI). This analysis will measure (1) the soundness of the investment and (2) the amount saved and functional areas impacted.

7.4.2 Methodology

7.4.2.1 The first step is to determine the current cost (status quo).

The development of current costs required gathering O&S costs for the OSI material onboard the aircraft carrier and submarine. From the collected data, only those items that were likely to be impacted by the RFID insertion were considered. The costs included are:

- Causative Research- Costs associated with searching for a lost item and a rough order of magnitude replacement cost.
- Manpower- Cost of personnel to conduct inventories and to process lost material requisitioning paperwork.
- Readiness- Cost of maintaining an accurate OSI database, and a rough order of magnitude impact of this on operational effectiveness.

7.4.2.2 The second step is to determine implementation costs of proposed solution.

The components of investment are:

- RFID COTS Pilot Testing- Cost of customizing/ testing commercial products.

- Procurement- Cost of purchasing and fielding integrated systems for aircraft carriers and submarines.

7.4.2.3 The third step in the process is to determine the impacted functions and expected savings.

The savings were calculated using the following methods:

- Elimination of efforts that would no longer be required.
- Reduction in effort for non-value-added activities.

7.4.2.4 The final step is to conduct the financial analysis.

- All assumptions must be clearly stated.
- Data sources must be referenced.
- Gaps in the data must be identified.

7.4.3 Financial Analysis

<u>Assumptions</u>:

- aircraft carrier life 50 years, submarine 30 years
- Assumed a 20% loss rate for material over ship's life prior to RFID, and 10% after insertion of RFID
- Manpower estimates for inventorying were based on a rough order of magnitude assessment from USS Connecticut (SSN-22) at 500 man-hours per year for MAMS and SPETRAL equipment
- A man-year was defined as working 200 days at 8 hours/day
- Average cost of OSI material is $100/item on carrier and $500/item for submarines

Validated Data:

- 35,000 OSI carried on board aircraft carrier, 3715 onboard subs
- One enlisted man-year costs approximately $75,000

Sources:

- James Sillman, CVX program office provided man-year cost estimate for enlisted personnel.
- Robert DeSantis, SUPSHIP Groton CT for submarine logistics material quantities, manpower estimates and rough order of magnitude estimates on cost savings associated with employing RFID.
- Trish Terrien, SUPSHIP Newport News Shipbuilding for aircraft carrier logistics material quantities, average cost per item for OSI material, and a breakdown of the various categories of OSI gear requiring periodic inventorying.
- Cost estimates for RFID gear based from Rick Heimann of Texas Instruments for the TIRIS passive RFID tags and associated portable readers.

This analysis compares the cost to the Navy, if the RFID system is not implemented (status quo), against the cost to the Navy, if the system is implemented (proposed). The results from this analysis offer a conservative, rough order of magnitude, assessment of the potential savings of applying RFID technology for OSI material tagging. Insufficient hard data on the lifecycle management of this material was available to support a rigorous sensitivity analysis, but this is not considered to be a major issue since the cost savings of this implementation were so large; however, it may be an issue for BCA's conducted for other applications.

7.4.3.1 Status Quo

Investment: There is no investment cost with the Status Quo system.

Operation and Support (O&S)

Causative Research:

- For the aircraft carrier the total causative research cost is $700,000 for the aircraft carrier which is derived by taking the total number of OSI items (35,000) times the average cost of those items ($100/item) times a 20% loss rate over the ship's life.
- For the submarine the total causative research cost is estimated to be $370,000 which is derived by taking the total number of OSI items (3715) times an average cost of those items ($500+/item) times a 20% loss rate over the ship's life.

Manpower :

- For the aircraft carrier the total manpower expense is estimated to be $1,172,000 based on 25,000 man-hours spent over the ship's 50 year life which equates to 15.6 sailor- years worth of effort at an estimated ($75,000/year cost).
- For the submarine the total manpower expense is estimated to be $705,000 based on 15,000 man-hours spent over the ship's 30 year life which equates to 9.4 sailor -years worth of effort at an estimated ($75,000/year cost).

7.4.3.2 Proposed Solution employing RFID

Investment: RFID procurement cost

For the aircraft carrier:

Equipment	Quantity	Cost
Passive RFID tags	35,000 at $1/tag	$35,000
Portable Readers	4 at $2000/unit	$8000
Installation Costs	35,000 at same cost as barcode	$0
Total Cost		$43,000

For the Submarine:

Equipment	Quantity	Cost
Passive RFID tags	3715 at $1/tag	$3715
Portable Readers	2 at $2000/unit	$4000
Installation Costs	35,000 at same cost as barcode	$0
Total Cost		$7715

Operation and Support (O&S)

Causative Research:

- For the aircraft carrier the total causative research cost is estimated to be $350,000 for the aircraft carrier which is derived by taking the total number of OSI items (35,000) times the average cost of those items ($100/item) times a 10% loss rate over the ship's life.
- For the submarine the total causative research cost is estimated to be $185,000 which is derived by taking the total number of OSI items (3715) times an average cost of those items ($500+/item) times a 10% loss rate over the ship's life.

Manpower :

- For the aircraft carrier the total manpower expense is estimated to be $117,200 based on 2,500 man-hours (10% of that time spent prior to the RFID insertion) spent over the ship's 50 year life which equates to 1.56 sailor- years worth of effort at an estimated ($75,000/year cost).
- For the submarine the total manpower expense is estimated to be $70,500 based on 1,500 man-hours (10% of that spent prior to the RFID insertion) spent over the ship's 30 year life which equates to .94 sailor -years worth of effort at an estimated ($75,000/year cost).

7.4.3.3 Total Lifetime Cost Saving Comparison

Aircraft Carrier

	Status Quo System	Proposed RFID System	Cost Difference
Causative Research	$700,000	$350,000	($350,000)
Manpower Expense	$1,172,000	$117,200	($1,054,800)
Investment Cost	$0	$43,000	$43,000
Total Costs	$2,200,000	$539,000	($1,361,800)

Submarine

	Status Quo System	Proposed RFID System	Cost Difference
Causative Research	$370,000	$185,000	($185,000)
Manpower Expense	$705,000	$70,500	($634,500)
Investment Cost	$0	$7,715	$7,715
Total Costs	$1,310,000	$284,715	($811,785)

7.4.4 Conclusion

This financial analysis, albeit founded on sparse data, does indicate that an investment in RFID for OSI tracking will reduce lifecycle costs by over $1 million when implemented onboard the aircraft carrier or submarine. It is also likely that collateral benefits to the operational posture of the ship, and to the larger Navy logistics infrastructure will also occur. A payback of investment cost to annualized total cost savings indicates that this application of RFID will pay for itself in just over a year. This is a very conservative assessment in that no credit was taken for the added savings of avoiding requisitioning costs, replacement material shipping costs or time spent by off-hull personnel

It is the ripple effects throughout the overall integrated supply chain which will generate big savings. And it is through the innovative leverage of the robust computer based IT infrastructure of the fleet and Navy at large that we are likely to find the greatest lifecylce and manning reductions in the years ahead. IT insertion to support this goal will require a teamed effort across various ship programs, and it will require the combined resources of Academia, Navy Labs, Ship Design Engineers and Managers, the Fleet lifecycle customer, and the Navy and DoD-wide infrastructure managers. I personally look forward to engaging the effort of inserting IT into our 21st century fleet.

8 Conclusions

As can be seen from the rough BCA analysis for OSI gear only, it is apparent that the implementation costs are low and that the potential savings are greater than $1 million for both the aircraft carrier and the submarine. This financial analysis shows that manpower savings generated through the effective insertion of IT more than pays for the implementation cost of the technology itself. Furthermore, now that a robust computer infrastructure is in place onboard Naval ships, it is likely that leveraging of that resource toward enhanced automation will typically yield beneficial BCA results. As the use of IT continues to evolve the BCA's will need to also expand to cover the collateral benefit of providing area-wide or fleet-wide access to data. These benefits will fall into the categories of enhanced agility and improved overall combat effectiveness, and metrics will need to be generated to permit inclusion into the BCA framework.

The other cost driver for OSI lifecycle costs was for the search and reorder effort associated with lost material. In the case of the Nimitz (CVN-68), my discussions with ship's force and SUPSHIP personnel at Newport News Shipbuilding were that of the 200 tons of OSI gear which had been offloaded in support of their overhaul, that much of that material was not accurately inventoried and recorded during offload. This creates the scenario of potentially having to go through hundreds of pallet sized boxes and to somehow match the physical equipment which often times have no markings with the AEL's. It simply is not a feasible scenario, and the outcome is very likely going to result in a redundant reordering of material to avert the last minute crisis of not having what they need when the ship is re-outfitted near the end of the overhaul. Whereas this thesis was able to capture a reasonably accurate manpower savings cost, it was only able to establish a rough order of magnitude stab at the lost material replacement cost, but it does get the point across.

The obvious result from this analysis is that if material tagging technology can save manpower through automation, improve operational performance through inventory validity and material velocity improvements, and can furthermore provide battlegroup of

shore-side leadership with real-time logistics material and configuration data, then it is a technology that should be properly evaluated. As stated in the commercial sector analysis, the RFID vendors are poised to listen to specific customer needs and to help craft a total system solution to fit those needs. This equates to the potential of cooperative pilot testing as was done for NSWCIH in their OSP initiative. Furthermore, my belief is that the insertion of this technology can be made at a unit level or a platform level to provide a phased in approach to the Navy or DoD systems at large over time. This is a customer pull approach that is very consistent with what is going on in the commercial sector.

Thus, this thesis has characterized the NAVY and DoD vision toward a more agile fighting force for the 21st century. Have researched the current initiatives involving the insertion of IT for logistics, and readily identified that there is a gap in the investigation of RFID as a potential material tagging solution. This was subsequently addressed and presented in the product mix analysis, technical issue area, and did result in a recommended list of potential RFID applications for ships. This thesis did specifically capture the potential gains with using RFID to track OSI material, but it did not carry out detailed analysis for the general logistics and food items, nor did it fully evaluate the financial gains associated with applying the technology to configuration management issues. It is believed that the savings in these areas will be substantially bigger than the OSI scenario. These applications are much broader based and as such will require substantial analysis.

As an aside, it was pointed out by SUPSHIP Newport News that the Nimitz underwent a configuration verification on the west coast prior to proceeding into overhaul at a cost of $1.5-2 million, and that a similar effort and expense was subsequently conducted once the ship entered overhaul. Therefore, anything that can be done to reduce the cost of verifying installed configuration is likely to afford tremendous savings.

As mentioned in the Motivation for Research Section of this thesis, the logistics space and functional assessment has been traditionally pushed off to the end of the design, and

that in a lifecycle conscious environment today, this must be put at the front of design. This places manning reductions as a first priority, it then demands a total systems analysis of how these personnel are spending their time; it must then identify the key elements of the system where the insertion of IT can help. Throughout the migration there will be a shifting of key nodes and again it will be critical to determine how the sailors are spending their time. In the case of logistics movements on the ship, there is a lot of inefficient effort being expended across the board today. This is good in the sense that there is much room for improvement, but it is also bad in the fact that it is likely to take a lot of tweaking to get it just right.

The life cycle management of the force is an extremely complex and demanding task. Since a lot of the O&S demands are placed at the early stages of design where minimal logistics expertise is applied, a cultural change is required. Since the O&S budgeting process has been so diffused in years past, and since the process has been largely manual discrete database supported, it is not hard to realize why change was difficult. Fortunately we sit at a point where technology, fiscal constraints and the growing demand for an agile fighting force will force "Focused Logistics". The introduction of IT solutions such as RFID is virtually assured given the fiscal realities present in the acquisition environment today, but it must be concurrently supported with organizational change. This means that designing an Operation and Support (O&S) friendly solution with a reliable, integrated automation scheme is a must. This requires a mindset change, and design philosophy shift to apply "out-of-the-box" thinking toward applying emerging technology to today's needs. The real issue is whether the Navy as an organization can position itself in a productive way to leverage the successes from one organization or industry to the next. The Navy ship design, production, and lifecycle support system is very large, and as a single voice it should be able to drive toward common solutions for varied issues.

Standardization for the sake of interoperability, while at the same time promoting an environment that supports continuous process improvement is necessary. This will demand that inputs for improvement be formatted into objective Business Case Analysis

(BCA) formats and that as Admiral Reason stated in his "Sailing New Seas" article, "the gage of success will be life cycle cost per unit of combat effectiveness" with focused logistics as a key driver.

9 Appendices

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9.2 Glossary

ADLR	Aircraft Depot Level Repairable
ADP	Automated Data Processing
AEL	Associated Equipment List
AFRS	Armed Forces Recipe Service
AIT	Automated Identification Technology
AMAR	Ammunition Management Accountablity Review
AMEDD	U.S. Army Medical Department Asset Tracking Program
AMSH	Automated Material Handling System
ANSRS	Automated Non-Standard Requisitioning System
ASN	Advanced Shipping Notices
ATAC	Advanced Traceablilty and Control System
ATIS	Advanced Technical Information System
BCA	Business Case Analysis
BPI	Business Process Improvement
C4ISR	Command, Control, Communications, Computers, Surveillance, and Reconnaissance
CAD	Computer Aided Design
CALS	Continuous Acquisition and Lifecycle Support
CBS	Communication Base Stations
CFE	Contractor Furnished Equipment
CINC	Commander in Chief
CMD	Contact Memory Cards
COE	Common Operating Environment
COMNAVUSA	Commander in Chief Naval Forces USA
CONUS	Continental United States
CORBA	Common Object Request Brokerage Account
COSAL	Coordinated Shipboard Allowance Listing
COTS	Commercial-Off-the-Shelf
CVN	Carrier Variant Nuclear
CVX	Carrier Variant X
CWO4	Chief Warrant Officer Grade 4
DDS	Data Dictinary System
DGSA	DoD Goal Security Architecture

DII	Defense Information Infrastructure
DISN	Defense Information System Network
DLA	Defense Logistics Agency
DoD	Department of Defense
EDI	Electronic Data Interface
E-Mall	Electronic Mall
EPL	Electronic Price Label
EPL	Electronic Price Label
ERP	Electronic Resource Planning
ERP	Enterprise Resource Planning
FACTS	Fleet Automated Control Tracking System
FARA	Federal Acquisition Reforem Act
FASA	Federal Acquisition Streamlining Act
FRAM	Fleet Resource Accounting Module
FSM	Food Service Management
GCCS	Global Communication Support System
GFE	Government Furnished Equipment
GUI	Graphical User Interface
HAZMAT	Hazardous Materials
IATA	International Air Transport Association
IDL	Interface Definition Language
ILS	Integrated Logistics Support
IRM	Information Resource Management
IRR	Internal Rate Of Return
IRRD	Issue Release/Receipt Document
ISCM	Integrated Supply Chain Management
ISP	In-Store Processor
IT	Information Technology
IT-21	Information Technology 21st Century
ITI	Industrial Technology Institute
JCALS	Joint Compatible Automated Logistics System
JCN	Job Control Number
JECPO	Joint Electronic Commerce Program Office
JIT	Just -In-Time
JMCIS	Joint Military Command Information System

JV 2010	Joint Vision 2010
LAN	Local Area Network
LDS	Logistics Data System
LOE	Level of Effort
LOS	Line of Sight
LSA	Logistics Support Analysis
MARC	Multi-Technology Automated Reader Card
MEMS	Microelectromechanical systems
MHIMS	Material Handling Information Management System
MHP	Material Handling Processes
MRMS	Maintenance Resource Management System
MRP	Maintenance Resource Management System
NALCOMIS	Naval Aviation Logistics Command Management Information System
NAVSUP	Naval Supply
NCTSS	Naval Tactical Command Support Systems
NECO	Navy Electronic Commerce On-Line
NFESC	Naval Facilities Engineering Service Center
NII	National Information Infrastructure
NPV	Net Present Value
NSIN	National Stock Identification Number
NSSF	Naval Submarine Support Facility
NSWCIH	Naval Surface Warfare Center-Indian Head
O&S	Operation and Support
OL	Unfilled Order Listing
ONR	Office of Naval Research
OSE	Open Systems Environment
OSI	Operating Space Item
OSP	Ordnance Storage Project
PC	Personal Computer
PNS	Portsmouth Naval Shipbyard
POC	Point of Contact
POS	Point of Sale
QUADS	Quality Application and Database Suite
R/W	Read/Write

RDBMS	Relational Database Management System
RFID	Radio Frequency Identification Device
ROI	Return on Investment
ROMIS	Real Time Outfitting Management Information System
ROMIS	Retail Operations Management
RSVP	Remote Sensing by Virtual Presense
RTT	Recording and Tracking Technologies
SFOEDL	Summary Filled Order Expenditure Difference Listing
SMARTS	Shipboard Material Automated Reconciliation Tracking System
SMP	Smart Product Model
SNAP	Shipboard Non-tactical Application Programs
SQL	Structured Query Language
SRI	Store Room Items
STARS	Standard Accounting and Reporting System
SUADPS	Shipboard Uniform Automated Data Process SystemNon-tactical Application Programs
SUPPO	Supply Officer
SUPSHIP	Supervisor of Shipbuilding
TAFIM	Technical Architecture Framework for Information Management
TAV	Total Asset Visibility
TCMD	Transportation Control and Movement Documents
TCN	Transportatin Control Numbers
TI	Texas Instruments
TRM	Technical Reference Model
UNREP	Underway Replenishment
VCI	Value Chain Initiative
VERTREP	Vertical Replenishment (Helicopter)

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9.4 Financial Analysis Source Data

This Section provides the financial data that I received from SUPSHIP Newport News on behalf of aircraft carriers, and from SUPSHIP Groton on behalf of submarines. This data represents only a rough order of magnitude assessment of potential gains associated with employing RFID, and some thumbrules for tying costs to certain types of material. This was data was used for the BCA analysis provided in Chapter 7 of this thesis with added assumptions annotated.

9.4.1 SUPSHIP Newport News cost data

Information provided in 16 April email is as follows:

- 35,000 OSI line items onboard the carrier based on a breakdown of OSI by AEL rather than NSN. This equates to 12,500 NSN line items.
- A straight division of OSI material cost by line item number yields $1230.74 per item. This is biased by the high cost items, and it was recommended that a conservative value of $100/item be used for the analysis.
- SPETERL and MAMS are periodically inventoried.
- 5 SUPSHIP persons were fully employed for the 3 year construction period of USS Truman (CVN-75) to manage and track material with today's material tracking scheme.

9.4.2 SUPSHIP Groton cost data

- 3715 OSI items onboard the submarine.
- MAMS and SPETERL inventories take about 500 hours/year.
- Additional breakdown of logistics material management that reflects gross estimates of the benefit of employing RFID is provided in tabular in the following pages.

	NEW CONSTRUCTION FITTING OUT PROCESS	OLD / NEW	EB-M/H SAVINGS	NAVY-M/H SAVINGS
1.	RECEIVE / PACKAGE / WAREHOUSE (35% of process #s 1, 2, 3, 4 and 8), or 8750 of 25000 estimated man hours			
a	Receive material into ROMIS.	OLD / NEW		
b	Produce bar code label.	OLD / NEW		
c	Produce bar code / RFID label from ROMIS.	OLD / NEW		
d	Package material.	OLD / NEW		
e	Affix label to packaged material.	OLD / NEW		
f	Move labeled material to warehouse location. (OSI / SRI / Q / GUCL)	OLD / NEW		
g	Read each individual material bar code label and wand into location by reading location bar code label, then key stroke quantity into bar code reader.	OLD		
h	Batch read RFID labels placed in warehouse location using interrogator.	NEW		
I	Upload warehouse location data into ROMIS.	OLD / NEW		
*	OLD Process vs RFID: Potential man-hours reduction estimate from 8750 to 6250 man hours. Based on 2500 (10% of 25000) man hour reduction attributed to process step 1h.		2500	

2.	PREBIN (35% of process #s 1, 2, 3 , 4 AND 8), or 8750 of 25000 man hours			
a	Generate ROMIS Pick list.	OLD / NEW		
b	Pick (OSI / SRI / Q) item and move item to prebin location (locker or drawer).	OLD / NEW		
c	Read/Scan bar code label of each individual item. Read/Scan prebin location bar code, then keystroke quantity into bar code reader.	OLD		
d	Read RFID tags placed in prebin location.	NEW		
e	Place an active RFID tag on prebin location (drawer or locker mockup). Update active tag on prebin location with inventory content based on RFID tags prebinned in location.	NEW		
f	Upload prebin location data into ROMIS.	OLD / NEW		
*	OLD Process vs RFID: Potential man-hours reduction estimate from 8750 to 6250. Based on 2500 (10% of 25000) man hour reduction attributed to process step 2d.		2500	
3.	WAREHOUSE AUDIT (2% of process #s 1, 2, 3, 4 and 8), or 500 of 25000 man hours			
a	Contractor perform 100% warehouse audit for all prebinned items prior to SUPSHIP preload audit.	OLD / NEW		
b	Visually inspect each item in prebin location and manually verify against inventory list.	OLD		

c	Batch read RFID Tags in each prebin location.	NEW		
d	Electronically reconcile prebin inventory data with ROMIS.	NEW		
e	Research differences. Reconcile all inventory discrepancies, correcting ROMIS inventory data and/or adjust prebin item location or RFID tag as appropriate.	OLD / NEW		
*	OLD Process vs RFID: Potential man-hours reduction. Estimate From 500 man hours down to 125 man hours.		375	
4.	OTHER MISCELLANEOUS WAREHOUSE FUNCTIONS (28% of process #s 1, 2, 3, 4 and 8), or 7000 of 25000 man hours			
a	Shelf life item management. Potential RFID benefit.	OLD / NEW		
b	Level 1 / SUBSAFE material segregation. Potential RFID benefit.	OLD / NEW		
c	Expediting Material	OLD / NEW		
d	Setting up locker Mock-ups and drawers	OLD / NEW		
e	Trade Stow material management. Potential RFID benefit.	OLD / NEW		
f	Reactor Fill Material preparation	OLD / NEW		
g	Assisting Ship's Force	OLD / NEW		
h	Locating lost material. RFID will greatly reduce time searching for lost material, and prevent costly re-ordering material cost. Estimate 100 hours consumed per hull searching for lost material could be reduced to 10 hours.	OLD / NEW	90	
5.	SUPSHIP WAREHOUSE PRELOAD AUDIT (SRI and NUCLEAR) (300 NAVY man hours and 16 contractor man hours)			
a	Manually inventory 100% of 7700 Nuclear allowance items.	OLD		

b	Sample 500 selected SRI items from a population of 9000 items.	OLD		
c	Read 100% of Nuclear RFID tags in prebin locations.	NEW		
d	Read selected SRI prebin location RFID tags. Up to 100% possible with RFID tag read.	NEW		
e	Electronically reconcile prebin inventory data with ROMIS.	NEW		
f	Investigate and resolve discrepancies with contractor.	OLD / NEW		
g	Contractor support for PRE-LOAD Audit	OLD / NEW		
*	OLD Process vs RFID: Potential man-hours reduction. Contractor support man hours reduction from 16 to 4 hours. Navy audit man hour reduction from 300 to 8 hours.		12	292
6.	LOAD SHIP (400 lockers, estimate 1/2 hour per locker, 200 man hours) (drawer load estimate 48 man hours)			
a	Seal prebinned drawers in warehouse,	OLD / NEW		
b	Leave active RFID tag attached to drawer.	NEW		
c	Load sealed drawers on ship.	OLD / NEW		
d	Place prebinned bulk locker material into seabags.	OLD / NEW		
e	Remove active RFID tag from locker mockup.	NEW		

f	Load/pack bagged locker material into designated shipboard locker.	OLD / NEW		
g	Manually find each item on inventory load list and circle quantity.	OLD		
h	Place active RFID tag on inside of locker door.	NEW		
I	Read RFID tags in locker. Update active RFID tag on locker door.	NEW		
j	Batch issue by location in ROMIS.	OLD C120		
k	Electronically batch issue RFID tag data, updating ship location into ROMIS.	NEW		
*	OLD Process vs RFID: Potential man-hours reduction loading 400 lockers from 200 to 100 hours (50% reduction).		100	
7.	SUPSHIP POST LOAD AUDIT (60 NAVY man hours and 6 contractor man hours)			
a	SUPSHIP and FOSSAC sample audit 500 items (SRI / Q) loaded in shipboard locations.	OLD		
b	Read RFID tags in selected sample locations.	NEW		
c	Electronically reconcile shipboard RFID inventory data with ROMIS.	NEW		
d	Investigate and resolve discrepancies with contractor.	OLD / NEW		

e	Contractor support for Post Load Audit (6 hours).	OLD / NEW		
*	OLD Process vs RFID: Potential man-hours reduction. Contractor support man hours reduction from 6 to 2 hours. Navy audit man hour reduction from 60 to 4 hours.		4	56
8.	POST DELIVERY EXCESS MATERIAL PULL (200 hours)			
a	Pull excess material (3000 items) from warehouse locations.	OLD / NEW		
b	Wand each individual bar code label and key stroke quantity into bar code reader. Wand location bar code.	OLD		
c	Move material to excess location in warehouse.	OLD / NEW		
d	Update ROMIS with bar code reader data.	OLD		
e	Read RFID tags.	NEW		
f	Electronically batch issue RFID tag data from warehouse location to excess warehouse location in ROMIS.	NEW		
*	OLD Process vs RFID: Potential man-hours reduction. Estimate From 200 hours down to 160 hours.		40	
9.	NAVY MAN-HOURS NECESSARY FOR MATERIAL INVENTORIES CONDUCTED BY SHIP'S FORCE			
	Estimated man hour reductions identified below are based on RFID being used to conduct inventory during a one year period.			
a	MAMs - 2-3 weeks (1 person) Done semi-annually (240 man hours reduced to 24)			216

b	Q-IN USE 8-10 weeks (2 persons) Done quarterly (3200 man hours reduced to 320)			2880
c	SIM ITEMS 1 week (1 Person) Done semi-annually (80 man hours reduced to 32)			48
d	L1/SS 6-8 weeks (1 person) Done annually (320 man hours reduced to 40)			280
e	DLRs 12-14 weeks (2 persons) Done annually (over 1,000 line items) (1120 man hours reduced to 40)			1080
f	SHELF LIFE 10-12 weeks (2 persons) Done annually (96 man hours reduced to 40)			56
g	CLASSIFIED MATL 2 days (1 person) Done annually (16 man hours reduced to 4)			12
h	2SX1 2 days (1 person) Done quarterly (64 man hours reduced to 4)			60
	The above times were provided by the USS CONNECTICUT Leading Storekeeper. Navy man hour savings are annual			
	The above figures are based on the fact that no major problems are encountered. If any major problems are identified an additional inventory time of up to four weeks would be required by ships force.			
10.	TOTAL POTENTIAL MAN HOUR REDUCTION		5621	4980

9.5 RFID Vendor Listing

This RFID vendor listing represents the compilation of data across a couple thesis projects over the past year here at MIT. The most important comment to make with this list is that it continues to evolve, and the prices and capabilities of the product lines continue to expand. A listing of RFID vendors, and other particularly useful RFID product summaries are also provided in this appendix to assist the reader in carrying out their own internet search.